ADVISABILITY OF CHANGING THE MUNICIPAL SHOPS TO MOTOR DRIVE

W. F. PARKER

ARMOUR INSTITUTE OF TECHNOLOGY

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Parker, W. F.
The advisability of changing
the municipal shops to

A THESIS

PRESENTED BY

W. F. PARKER

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

~~BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING~~
ELECTRICAL - ENGINEER
~~HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN~~

ELECTRICAL ENGINEERING

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PREFACE

A STUDY MADE FOR THE

"DEPARTMENT OF ELECTRICITY"

CITY OF CHICAGO.

By — W. F. Parker.

On — The advisability of changing the municipal shops to motor drive, using power from the system of the Sanitary District of Illinois.

Submitted to — The President, Faculty and Board of Directors of Armour Institute of Technology.

For — The Degree of Electrical Engineer.

May 22, 1909.

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First Floor Plan Water Pipe Extension Machine Shop

Balcony " " " " " " "

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Pipe Shop " " " " "

Fan House " " " " "

Police Department

First Floor Plan and Blower Room.

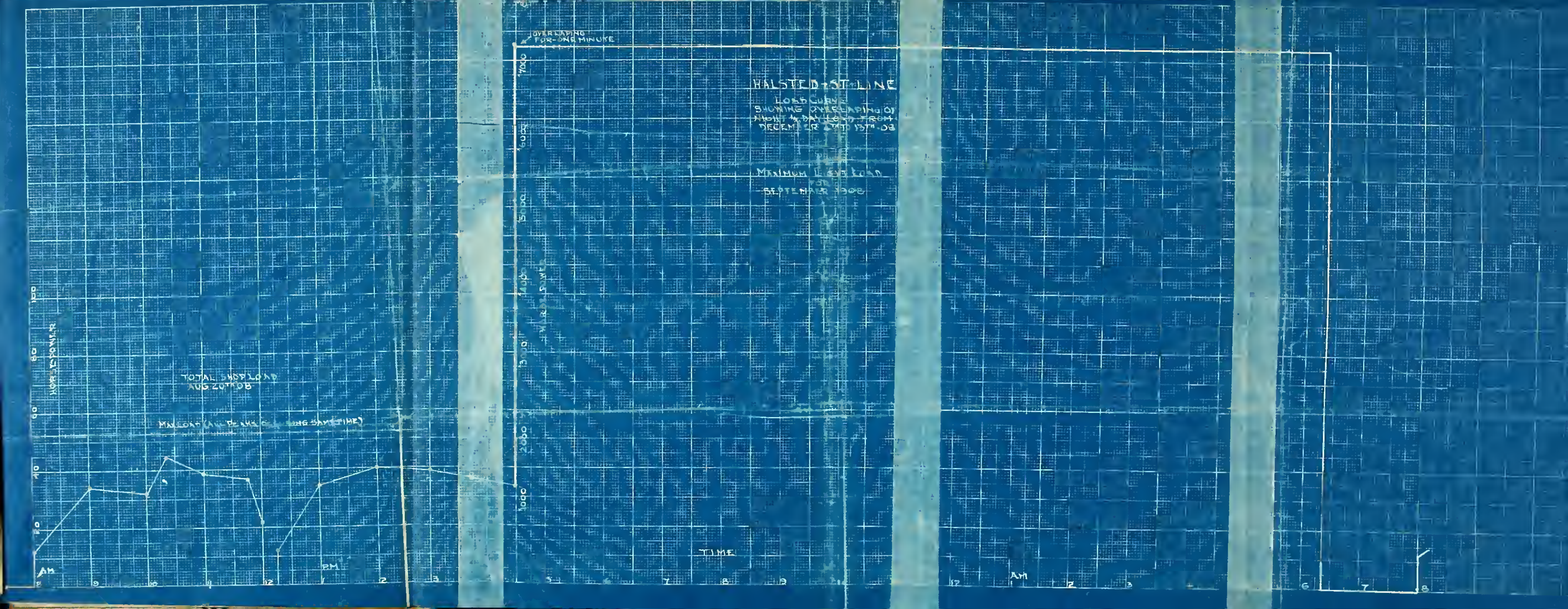
Saw Mill Floor Plan Water Pipe Extension Department

Load Curve Water Pipe Machine Shop

" " Police Shop

" " Total (showing overlaping) day and night load.

Motor Characteristics.



HALSTED-ST-LINE

LOAD CURVE
SHOWING OVERLAPPING OF
NIGHT & DAY LOAD FROM
DECEMBER 2ND TO 13TH 08

MAXIMUM [illegible] LOAD
FOR
SEPTEMBER 1908

ARMOUR
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INTRODUCTION

At present the municipal shops located just south of Blue Island Ave. on Ashland Ave. are operated by steam and electricity in part.

The machine shop of the Water Pipe Extension Department is operated by means of a single cylinder double acting non-condensing engine. The power is transmitted to the various machines through belts, line shafts and jack shafts.

The shop of the Police Department is operated by means of two motors, one supplied from the Chicago Union Traction Company's trolley line which runs down Ashland Ave., the other from the Chicago Edison Company's lines.

The saw mill and wood shop of the Water Pipe Extension Department is also operated by a motor supplied current from the Chicago Union Traction Company.

Recognizing the fact that where belt drive is used with inherent line and jack shafting considerable power is lost in transmission; it is proposed to operate these various shops by electric motors supplied with power from the "Sanitary District". It is believed by so doing money can be saved in the operation of the shops, and at the same time the city load factor will be increased which will also result in a saving.

At present the"city" night load is considerably in excess of the day load, so any change that will tend to balance these conditions is desirable as it will allow the "city" to take advantage of the minimum twenty-four hour day rate which the "Sanitary District" is offering.

With this object in view and considering the increased efficiency with motor drive a thorough study was made; steam and electric tests were carried out in order to ascertain the present distribution of the load, percentage of losses, so that the adaptation of the proper size motor to the various machines or group of machines could be most economically made.

I wish to submit the following results:

WATER PIPE EXTENSION DEPARTMENT

MACHINE SHOP

PRESENT MOTIVE POWER

The engine which drives the various machines viz., shapers, drill-presses, lathes, planers, bolt threaders etc., in this shop is furnished steam from the pumping station which lies adjacent to and north of the shop. The steam is conducted through a (6") six inch main from the boilers through the basement of the station, across an area-way and then to the engine a distance of about 350 ft. This results in considerable condensation and loss in pressure which gives a poor quality of steam to the engine. The engine is located on the north side of the building quite a distance from the center of the load which it carries.

LOCATION OF MACHINES.

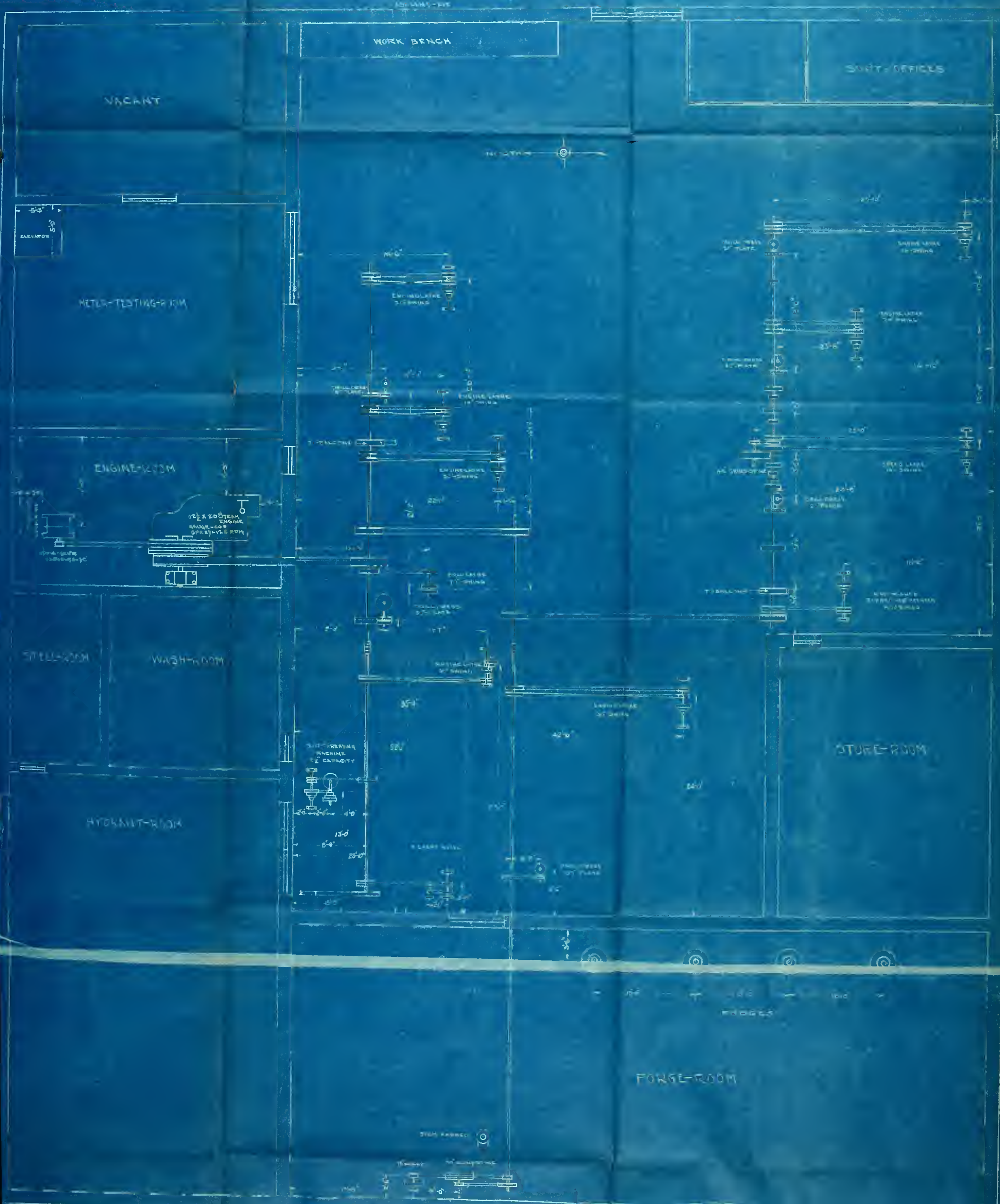
The various machines are located approximately as shown on the floor plan drawings attached hereto. A glance at these drawings will show that the power in order to reach the machines must be transmitted by belts and shafting over two floors which are about 125 ft. square. There is no system to the arrangement of the machines; they having been added from time to time and located in the most convenient rather than the most economical position.

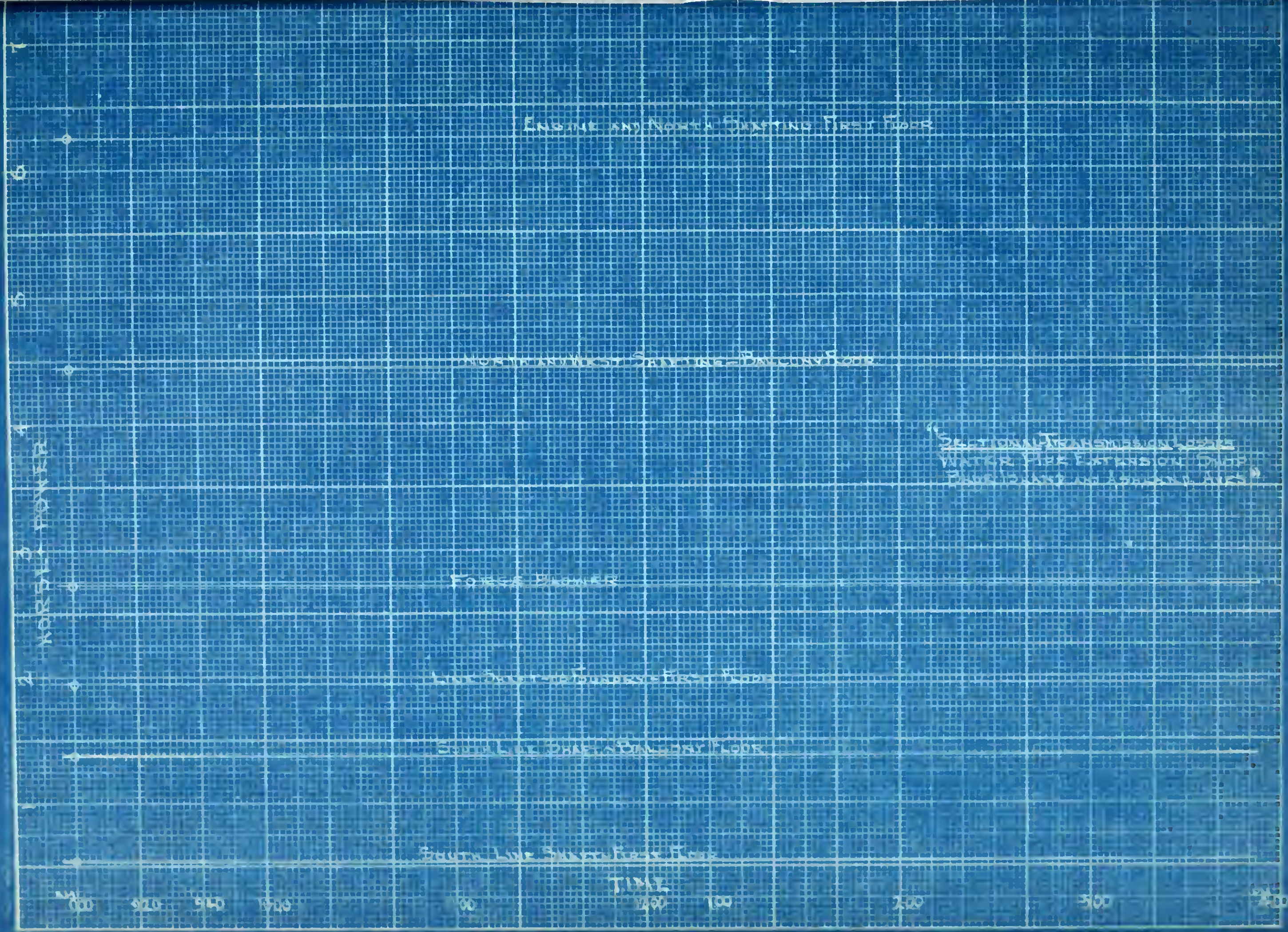
LOSS IN TRANSMISSION AND FRICTION

From the steam test which was conducted on this plant the total and sectional transmission losses were obtained; which appear on the blue print attached hereto. An examination of this print will show the total transmission loss to be 14.57 horse power which

WATER-PIPE-EXTENSION-SHOP
CITY OF CHICAGO
[illegible]

PRESENT FIRST FLOOR PLAN




Engine and North Shafting First Floor
North and West Shafting—Balcony Floor
"Sectional Transmission Losses
Water Pipe Extension Shop
[illegible]"
Force Blower
Line Shaft—Foundry—First Floor
South Line Shaft—Balcony Floor
South Line Shafting First Floor
HORSE POWER
1
2
3
4
5
6
7
TIME
A.M.
900
920
940
1000
1100
1200
100
200
300
P.M.
400

if expressed in terms of full load (average) amounts to 53%. This loss is increased when the machines are running under load because the tension in the belts are greater and the loss in the journals of the shafting increases. This is an actual loss of power for which the "city" is paying and realizing nothing in return. With the present arrangement of the machines this loss will exist as long as the shop is running, regardless of whether the machines are being used for useful work or not.

SECTION TRANSMISSION LOSSES.

In the line shafting, belts and inherent jack shafting running along the south balcony and extending to the pattern room (see floor plan),there is a loss of 1.37 horse power.

In the shafting and belts along the north and west sides of the balcony there is a loss of 4.45 horse power.

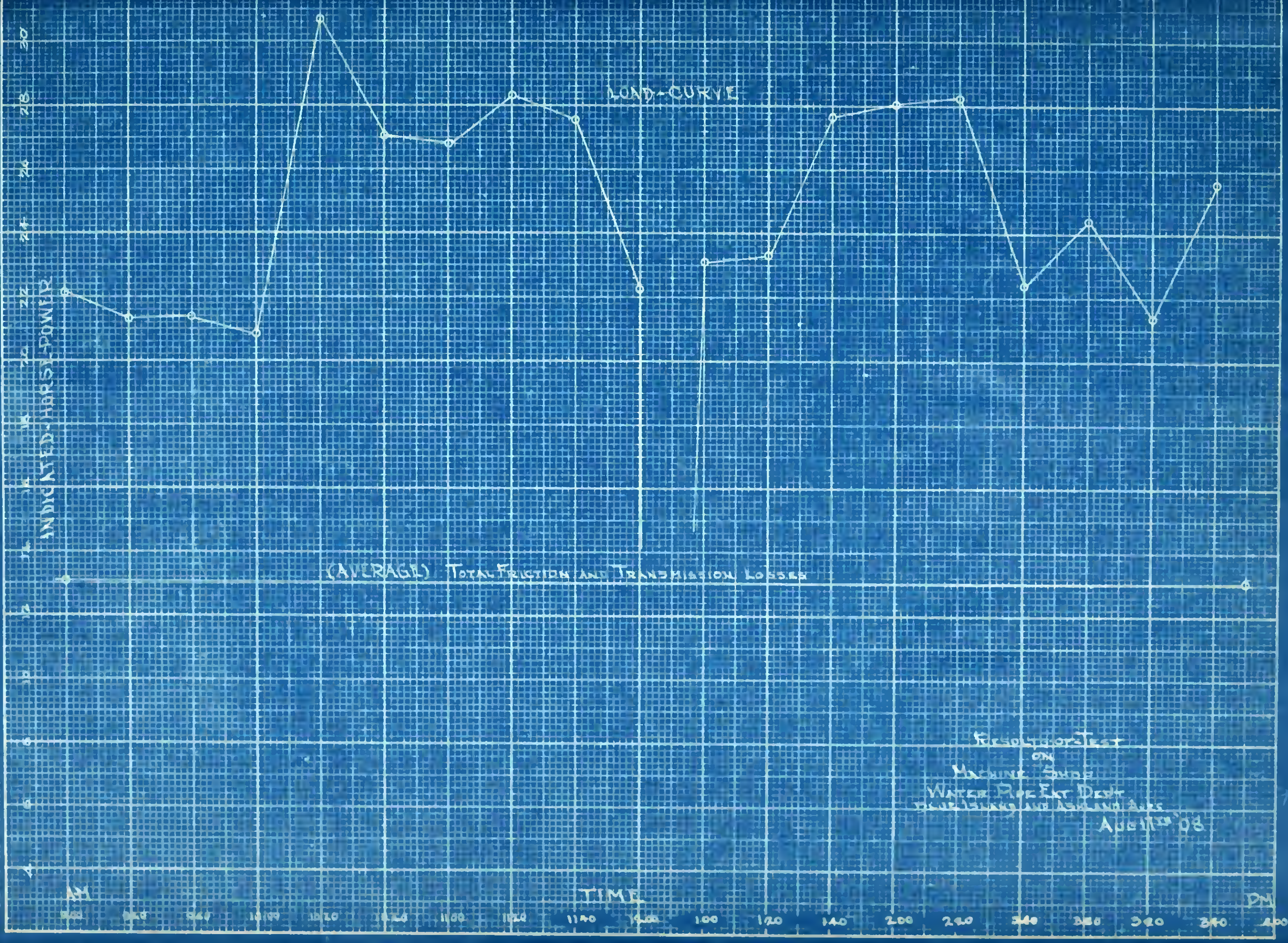
On the first floor south line the loss amounts to .55 horse power, the foundry line 1.95 horse power and the north line and engine losses 6.25 horse power.

The sectional transmission loss curves show just how the loss of power is distributed throughout the shop.

LOAD CURVE

The load curve of this shop obtained from the steam cards show an average of 24.9 horse power while the maximum ran as high as 30.7 horse power.

The demand at times is considerably in excess of this, however, but the engine will not deliver an appreciable amount above the maximum demand shown on the load curve; even though the



RESULTS OF TEST
ON
MACHINE SHOP
WATER PIPE EXT DEPT
BLUE ISLAND AND ASHLAND AVES
AUG 11TH 08

governor be adjusted for the engine to take steam to one-half stroke.

It is apparent therefore that in order to be able to take care of the maximum shop load at present and also allow for growth, a larger unit must be installed or other provisions made.

Water Rate — The average amount of steam consumed by the engine per indicated horse power hour was obtained from seventy steam cards which is 20.877 pounds.

PRESENT COST OF POWER

The pumping station's charge to the Water Pipe Extension Department for steam furnished in the operation of this engine is four (4) tons of coal per day at $2.60 per ton.

The daily cost is therefore $2.60 x 4 = $10.40.

The weekly charge 5-1/2 x $10.40 = $57.20

The yearly charge 52 x $57.20 = $2974.40

Steam Hammer

The steam hammer operating in the foundry room consumes 13 cu.ft. of free air per minute for every 100 pounds of falling weight of the hammer.

Capacity of the hammer 1600 pounds.

Consequently the steam consumed per hour at 60 pounds gauge or 74.7 absolute pressure, (basing our calculation on the theory that the steam obeys the law of a perfect gas) will be

$$\frac{1600}{100} \times 13 = 208 \text{ cu.ft.}$$

$$\frac{14.7 \times 208}{74.7} = 41 \text{ cu.ft.}$$

41 cu.ft. x .1785 x 60 = 439 pounds per hour. In as much as this hammer takes steam at boiler pressure throughout its

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SALESROOMS:

NEW YORK, 23 DEY STREET.

CHICAGO, 15 W. LAKE STREET.

INDICATOR DIAGRAM.

Taken.......................................190 ......

Engine at ....

Diam of Cylinder......................inches

Stroke.......................................inches

Speed................................revolution

Boiler Pressure..............................lbs.

Clearance..............................per cent.

M. E. P.......................................lbs.

Scale of Spring.....................lbs. per in.

Vacuum......................................inches

Hot Well..............................Deg. Fahr.

Horse Power......................................

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Hot Well..............................Deg. Fahr.

Horse Power......................................

ARMOUR
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[illegible]

[illegible]
[illegible] POLOGY

DATA FROM INDICATOR CARDS

Cards taken from 12½" x 20" SIMPLE ENGINE Aug 31st 190
Integrated by W J Parker Results compiled by W J Parker
Checked by W J Parker Indicator used Schaeffer and Budenburg
Scale of spring 20# AND 50# POUNDS Average water rate from diagram at Cut off 20.377#
Length of stroke 1.66 feet HEAD-END Area piston 124 sq in

Number	CUT-OFF % OF STROKE	RELEASE % STROKE	M-E-P	M E P Corrected	R.P.M	I.H.P	ABSOLUTE PRESSURES				POUNDS STEAM per I.H.P. HOUR	REMARKS
							CUT OFF	RELEASE	BACK	ADMIS-SION		
1	6.473	99.9	7.925	7.825	126	6.25	53.6	14.3	14.8	54.7	17.1	TOTAL-SHAFTING
2	7.66	99.9	6.45	6.45	124	5.07	53.6	12.9	14.7	54.7	21.6	50' BALCONY-OFF
3	4.97	99.9	4.15	4.15	125	3.29	48.0	11.58	14.7	49.7	19.8	FIRST FLOOR SHAFTING
4	5.30	98.0	3.47	3.47	125	2.75	46.9	13.50	14.7	47.8	24.3	50' LINE 1ST FLOOR-OFF
5	5.35	97.8	2.75	2.75	125	2.18	41.0	11.50	14.7	42.9	27.3	FORGE SHOP LINE-OFF
6	6.473	98.0	6.65	6.65	126	5.32	59.0	14.30	14.7	59.4	19.5	TOTAL SHAFTING
7	7.78	97.6	9.30	9.30	126	7.41	55.3	14.7	14.7	59.4	16.0	TOTAL SHAFT AND FAN
8	11.20	99.9	10.625	10.625	125	8.40	52.1	14.7	14.7	54.0	19.0	TOTAL SHAFT AND FAN
9	11.58	95.6	6.4	6.4	123	5.00	40.0	10.9	14.7	46.0	25.0	FIRST FLOOR SHAFTING
10	5.78	97.3	5.1	5.1	124	4.00	45.0	11.58	14.7	45.9	17.6	
11	8.75	96.5	4.5	4.5	125	3.565	32.2	12.2	15.0	45.1	21.6	
12	9.07	97.8	5.6	5.6	124	4.4	42.9	10.8	14.7	45.9	23.0	
13	9.92	97.6	5.5	5.4	123	4.22	39.8	11.66	14.8	42.9	25.4	
14	13.20	9.98	8.625	8.625	120	6.56	40.8	11.1	14.7	46.9	21.2	TOTAL SHAFTING
15	11.15	98.0	8.625	8.625	122	6.7	48.0	10.2	14.7	49.1	22.1	
16	14.15	97.7	7.50	7.30	130	6.02	60.4	13.15	14.9	62.8	38.8	
17	9.90	97.7	13.75	13.75	125	10.90	60.8	17.22	14.7	61.7	16.8	WORKING-LOAD
18	11.60	96.5	14.10	13.90	120	10.60	57.2	17.00	14.9	57.2	16.4	
19	9.90	97.6	13.70	13.50	124	10.62	58.0	17.20	14.9	58.4	15.9	
20	11.95	98.9	14.0	13.7	123	10.69	56.8	16.80	15.0	57.4	16.8	
21	21.40	99.2	23.1	22.0	117	16.31	59.3	22.20	16.8	61.2	19.5	
22	14.90	97.4	18.3	17.9	120	13.75	58.0	19.65	15.1	59.7	16.3	
23	20.20	98.3	21.4	19.6	114	14.15	57.8	22.2	16.5	58.4	20.4	
24	18.20	100.0	19.5	19.4	118	14.28	57.2	17.24	15.1	59.1	18.4	
25	16.50	99.9	19.5	18.9	118	14.15	60.1	19.7	15.3	60.9	17.8	
26	16.90	100.0	15.50	15.10	118	11.30	49.0	17.85	15.1	52.19	18.7	
27	14.56	99.4	14.75	14.75	123	11.50	53.7	17.04	14.7	55.3	17.9	
28	14.08	99.9	15.0	15.0	124	11.80	55.3	15.0	14.7	55.3	17.6	
29	18.40	98.3	20.25	19.75	118	14.75	56.1	20.7	15.2	56.8	17.9	
30	26.40	99.2	19.5	19.2	116	14.20	46.2	19.38	15.0	55.3	21.6	
31	12.25	99.9	14.12	14.07	126	15.05	58.0	15.0	14.9	58.4	18.3	
32	20.25	99.2	20.0	19.8	120	11.20	51.7	14.9	14.8	53.0	17.6	
33	17.30	99.2	14.0	13.8	110	9.65	45.9	14.8	14.9	49.1	19.5	
34	12.80	98.9	14.75	13.95	121	10.75	56.1	16.26	15.0	58.45	17.4	
35	15.30	98.7	19.25	18.69	116	13.75	58.6	19.37	16.26	59.10	16.4	
CRANK-END												
1	8.68	99.9	10.3	10.30	126	8.23	54.6	14.3	14.7	56.2	17.1	TOTAL SHAFTING
2	8.26	99.9	10.22	10.225	124	8.04	51.3	12.9	14.7	53.5	16.5	50' BALCONY-OFF
3	7.03	99.9	6.80	6.8	125	5.38	49.0	11.58	14.7	51.0	23.1	FIRST FLOOR SHAFTING
4	10.73	97.4	6.825	6.825	125	5.40	45.0	13.00	14.7	45.3	25.4	50' LINE 1ST FLOOR & BALC'OF
5	10.73	98.0	5.10	5.10	125	4.04	39.7	12.30	14.7	39.7	28.4	FORGE SHOPLINE OFF
6	12.78	98.0	11.725	11.725	126	9.45	55.3	14.9	14.7	59.3	20.3	TOTAL SHAFTING
7	12.78	98.1	12.6	12.6	126	10.07	55.3	14.7	14.7	59.3	18.0	TOTAL SHAFT & FAN
8	11.55	97.9	9.25	9.25	125	7.34	51.3	13.3	14.7	54.2	21.8	" " " " "
9	8.26	96.5	5.1	5.1	123	3.98	44.0	11.0	14.7	44.7	24.6	FIRST FLOOR SHAFTING
10	8.26	95.6	4.3	4.3	124	3.39	44.8	11.50	14.7	45.9	29.0	" " "
11	9.10	97.3	4.60	4.3	125	3.41	44.7	10.96	15.0	46.7	32.2	" " "
12	8.26	97.8	4.67	4.67	124	3.67	42.9	10.60	14.7	45.9	26.2	" " "
13	11.56	97.8	5.38	5.18	123	4.05	40.1	11.58	14.9	42.9	30.6	" " "
14	12.95	99.9	7.00	7.00	120	5.33	41.4	10.02	14.7	46.9	26.0	TOTAL SHAFTING
15	10.75	98.9	8.00	8.00	122	6.17	48.5	12.30	14.7	40.1	22.6	" "
16	7.85	98.5	9.25	8.95	130	7.40	56.5	12.20	15.0	56.7	16.7	" "
17	12.00	98.4	14.00	14.00	125	11.10	61.4	17.1	14.7	49.1	17.6	WORKING-LOAD
18	15.30	99.8	14.20	13.90	120	10.58	58.0	16.26	15.0	58.2	21.6	
19	11.95	97.2	13.70	13.5	124	10.60	58.6	17.80	14.9	59.7	17.4	
20	12.00	98.0	13.1	12.8	123	10.00	51.2	17.20	15.0	56.0	16.3	
21	21.50	99.2	22.2	20.02	117	14.20	61.3	20.20	16.88	62.2	23.05	
22	15.65	97.8	17.55	17.15	120	13.10	60.0	17.60	15.1	61.1	19.0	
23	16.80	98.6	19.50	17.40	114	12.55	59.4	18.70	16.8	59.4	19.3	
24	15.68	99.3	18.95	18.55	118	13.90	58.7	18.45	15.1	59.7	16.7	
25	14.88	99.3	18.30	17.70	118	13.25	61.6	18.46	15.3	62.2	17.4	
26	14.45	100.0	14.62	14.52	118	10.90	51.5	15.00	14.8	52.3	20.7	
27	14.90	99.9	14.75	14.75	118	12.76	56.1	17.7	15.2	58.45	19.5	
28	14.90	99.9	14.5	14.5	124	11.40	56.2	17.0	14.7	56.2	18.6	
29	18.60	98.4	17.5	17.0	123	11.50	55.3	15.0	14.7	56.8	23.4	
30	26.40	99.9	19.0	18.70	116	13.75	50.7	19.39	15.0	53.7	19.2	
31	13.40	99.7	14.0	13.90	126	11.12	58.6	15.43	14.8	59.2	22.7	
32	21.40	99.9	17.6	17.30	120	13.12	57.2	16.26	15.0	54.5	19.2	
33	31.40	99.2	21.5	21.10	110	14.70	47.5	20.95	15.1	50.7	24.0	
34	13.40	98.95	14.3	13.73	124	10.50	56.8	17.09	15.27	58.45	18.8	
35	15.68	98.2	17.5	15.94	116	11.72	58.5	17.82	16.26	60.0	19.4	

stroke we feel safe in assuming $\frac{30.1}{1.305} = 23$ pounds of steam will be consumed per horse power.

This gives us $\frac{439}{23} = 19.05$ H. P. furnished.

Cost per indicated Horse Power Hour.

If we assume the average load to be 24.9 horse power indicated, and working an eight hour day, which are the conditions in this shop; the horse power hours on the engine will be

24.9 x 8 = 199.2 H.P. hours per day.

The steam hammer operating an average of one-half hour per day will consume an amount of steam equivalent to 9.525 H.P. hours per day.

The total horse power hours per day are 208.725 H.P.Hrs.

For this amount of power we are charged $10.40 which is equal to $\frac{10.40}{208.725} = 4.99$¢ per horse power hour indicated or $114.20. per horse power year.

POUNDS OF STEAM PER POUND OF COAL

From the tabulated data obtained from the indicater diagrams attached hereto we obtained 20.877 as the average pounds of steam consumed per indicated horse power on the engine.

The steam hammer consumes 23 pounds of steam per indicated horse power.

This gives us a total of 4379.5 pounds of steam consumed per day. We are charged for 4 tons of coal per day or 8000 pounds which makes $\frac{8000}{4379.5} = 1.825$ pounds of coal per pound of steam furnished.

With the quality of coal used by the pumping station we feel safe in assuming that at least four pounds of steam are generated per pound of coal burned.

The price charged the Water Pipe Extension Department appears therefore to be sufficient to cover the expense of handling the coal, generating the steam and delivering it to the engine and hammer. This is mentioned here to show that the charges made for power is not excessive.

CONDITION OF LOAD

From the load curve which shows a maximum of 30.7 horse power and an average of 24.9 horse power we obtain a factor of approximately 81%. This high percentage is due to the fact that a man is stationed at almost every machine in the shop. Under such conditions of operation individual motor drive will not prove any advantage or saving over grouping of machines if properly carried out.

DRAINAGE BOARD POWER

Cost — The Drainage Board offers to the city a net rate of $26.40 per horse power year with the privilege of using it 24 hours a day and 365 days per year, or a rate of $15.00 a horse power year operating for eleven hours (average) a day and 365 days a year.

These rates are not for integrated power but for maximum demand.

The bills are rendered each month and cover the peak for that particular month.

The cost per horse power hour is .301 metered at Western Ave. and 31st St. which is the location of the Sanitary District Sub Station, at the 24 hour rate.

The transmission loss at 70% power factor on the line which will feed the shops is so small that it has been neglected.

If the city can balance the day and night load so as to warrant paying for power 24 hours in the day, the above minimum rate can then be taken advantage of.

For the present a flat rate of $.02-1/2 per integrated horse power hour has been offered by the"Sanitary District" and it is this rate on which this study has been made to ascertain the advisability of changing to motor drive.

MOTOR EQUIPMENT

PATTERN ROOM

The pattern room contains two wood lathes 10" and 24" respectively and one 36" band saw. These machines are operated at present from the line shaft extending along the south balcony; the power being transmitted to them; by belts to an additional line shaft and three jack shafts; the latter containing drive, loose and cone pulleys.

Group versus Individual Drive.

In order to drive these machines separately it would require on the

36" band saw	a 2 H.P. motor cost	$63.00
10" wood lathe	a 1" " " "	52.00
24" " "	" 1/2 H.P." "	42.00

This makes a total cost for motors alone of $157.00.

To drive them with a single motor of three horse power capacity will cost $72.00.

I recommend the latter method as being the most economi-

cal, as additional shafting which will be driven when only one machine is used will be quite light and consequently the loss due to this wouldn't pay for the additional investment necessitated by individual drive.

I recommend the segregation of this room from the rest of the shop: first, because the machines remain idle for days at a time, second: because the main line shaft can be shortened about 25 ft., two 18" iron pulleys, and one jack shaft with driving and loose pulley can be put out of service.

I estimate this to reduce the transmission loss in this section 50% or a saving of .685 horse power which amounts in one year to $78.22. This alone will pay for the installation and leave a net balance of $7.95. This is in excess of any saving that will be made in operation with electricity compared with steam.

SOUTH BALCONY MACHINES

Group versus Individual Drive.

For individual drive it will be necessary to install on the

16" speed lathe 1 H.P. motor cost	$52.00
16" " " " " " " "	52.00
18" " " " " " " "	52.00
Total	156.00

Grouping will take 1-3 H.P. motor $72.00.

The remaining loss in this shafting after removing the pattern room is .685 H.P. which amounts to $78.22 per year.

With the individual drive possibly .5 H.P. could be saved, or $57.10 per year. With the group drive .21 H.P. which is the

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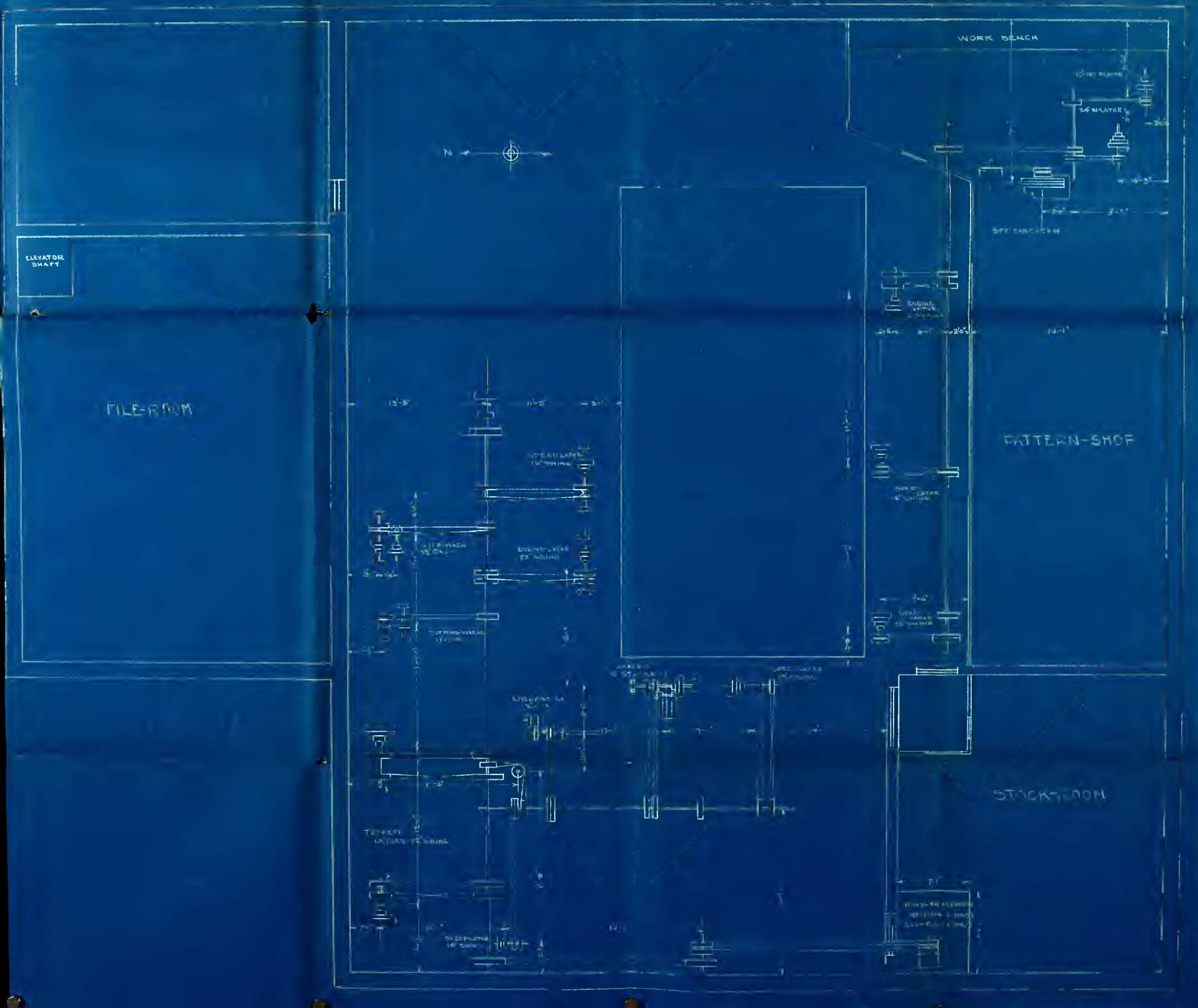
WATER-PIPE-EXTENSION-SHOP

CITY OF CHICAGO

ASHLAND AND BLUE ISLAND AVES

PRESENT - SECOND FLOOR - PLAN



difference in efficiency in favor of the large unit would be saved.

A better arrangement of the jack shafts and the removal of the 36" cast iron drive pulley on the line shaft we assume will save at least .1 H.P. which amounts to $11.42 per year.

As there is a man stationed at each of these lathes we recommend the installation of the 3H.P. motor. The saving made by individual drive will hardly warrant the investing of the difference in the cost of the three 1 H.P. motors and the one used for the group.

NORTH AND WEST LINES.

On the north and west lines of the balcony there are operating

12" speed lathe	requiring	1/2	H.P.	motor	$42.00
22" engine "	"	1	" "	"	52.00
3-1/2" pipe machine	"	1	" "	"	52.00
12" Buffing wheel	"	1/2	""	"	42.00
12" emery "	"	"	" "	"	42.00
22" turrett lathe	"	2	" "	"	63.00
22" " "	"	2	" "	"	63.00
18" Speed "	"	1	" "	"	52.00
16" " "	"	1	" "	"	52.00
18" " "	"	1	" "	"	52.00
18" shaper "	"	2	" "	"	63.00
Total					$575.00

In driving these machines as a group will necessitate the installation of one 10 H.P. motor, cost $226.00.

Assuming a loss of 1 H.P. in jack shafting which must be

used in either case there will be a saving of 3 H.P. with the individual drive which is equivalent to $342.40 per year.

By group drive there can be thrown out of service the west line shaft which is 32 ft. long and 1-3/4 inches in diameter, with 3 cast iron pulleys ranging from 12" to 24" in size, one vertical shaft with two (12") twelve inch idlers and 6 iron pulleys on the north line shaft ranging from 12" to 48" diameter.

We estimate this saving to be 2 H.P. which amounts to $228.40 per year.

There will also be a saving in favor of the higher efficiency of the 10 H.P. motor.

Hence using the group drive, installing one motor, the amount saved per year in transmission will pay for the investment and leave a credit balance. This is excepting the amount which will be saved by using "Sanitary District" power.

ELEVATOR

The elevator requires a 3 H.P. motor – cost $72.00. I recommend a separate motor for this elevator because it is used very little, possibly two or three times per day.

By this installation the transmission losses in two jack shafts, belts and 6 iron pulleys 36" in diameter is saved which is .5 horse power, equivalent to $57.10 per year. This saving will almost pay the cost of the investment.

FIRST FLOOR

SOUTH LINE SHAFT

Connected to this line shaft there are

26" Drill Press	requiring	2 H.P.	motor	$63.00
20" " "	"	1 " "	"	52.00
20" " "	"	1 " "	"	52.00
24" Engine Lathe	"	2 " "	"	63.00
24" " "	"	2 " "	"	63.00
16" Speed Lathe	"	1 ""	"	52.00
28"x28"x7' Planer	"	5 " "	"	78.00
42" Grind Stone	"	1 " "	"	52.00
Total				$475.00.

For group drive a 15 H.P. motor will be required, costing $255.00.

This shows a difference of $220.00 which the first cost of the individual drive is in excess of the group. The total transmission loss .55 H.P. is $62.80. Only about 80% could be saved with the smaller units, which wouldn't warrant the investment for small motors. The present transmission loss in this line may be appreciably reduced however by removing the 11 iron pulleys ranging from 6" to 36", which are not used. Other than this, the only saving here will be due to the cheaper electric power.

FOUNDRY LINE SHAFT

A line shaft 72 ft. long 1-1/2" diameter extends from the machine shop through the wall to the forge shop (see floor plan). This shaft with its inherent pulleys, belts, etc., can be removed, which will eliminate a loss of 1.95 horse power and result in a yearly saving of $223.00.

The drill press attached to this line can be moved to the north shaft. The hydrant lathe however is advantageously located

at present as it permits the hydrants to be easily handled.

I recommend a slow speed (1140 R.P.M.) 2 H.P. motor installed here. Cost $79.00.

The emery and grind stone in the forge shop I understand may not be used, however, if they are a 2 H.P. motor will take care of them. Cost $63.00.

Hence it is seen that a saving of $81.00 will be realized by this change at the end of the first year after paying for the motors, not considering the saving in operating expenses, with electricity.

Forge Blower.

The forge blower which is belted to the north line shaft through a jack shaft can be driven by a 3 H.P. motor. Cost of motor $72.00.

I recommend, however, that this blower be placed in a more accessible position.

NORTH LINE SHAFT

The shaft belted direct to the engine carries a

30" drill press	requiring	2 H.P.	motor	$63.00
6" emery wheel	"	1 " "	"	52.00
30" drill press (trans. from foundry line)	"	2 " "	"	63.00
3-1/2 bolt threader	"	1 " "	"	52.00
30" engine lathe	"	2 " "	"	63.00
70" facing lathe	"	2 H.P.	"	63.00
30" engine lathe	"	2 " "	"	63.00
20" speed lathe	"	1 " "	"	52.00
18" " "	"	1 " "	"	52.00
				523.00

Forward	$523.00
6" drill press requiring 1/2H.P.motor	42.00
Total	$565.00
Saving per year in transmission 2 H.P.	228.40
Cost of motor investment, end of first year	336.60
Group drive will require a 15 H.P. motor. Cost	255.00

Estimated transmission saving at end of first year, by removing idle pulleys, 60" drive pulley and fan jack shafting

1.00 H. P.	$114.20
Cost of motor investment end of first year	140.80

This again I believe the better method when the saving in efficiency of larger motor, and original investment is considered.

STEAM HAMMER

The advisability of operating this hammer by compressed air, throwing the forge blower out of service and using the compressor also for the forges was considered.

The forges will take at 4 ounce pressure 3993 cu.ft. of free air per minute. To reduce from 60 pound pressure per sq.in. to 4 ounce pressure is not a feasible proposition.

The hammer will take 13 cu.ft. of free air per minute per 100 pounds falling weight of hammer when used intermittently.

Weight of hammer 1600 pounds.

Cu.ft. free air per minute 208 cu.ft.

A 10" x 12" air compressor pumping 165 pounds free air per minute may be used in connection with reservoir, to handle this work.

Cost of compressor	$470.00
Cost of 32 H.P. motor to drive	301.50
Total	771.50

This is the required investment, not considering cost of tank, installation and operation.

Alternative—

If this hammer is furnished steam from the pumping station and we are charged at the present rate viz., 4.99¢ for 23 pounds per hour, the operating cost will be $.95 per hour. It will not average being used more than 1/2 hour per day during the year. The yearly cost for steam then will be $135.90. I believe the latter method to be the better and cheaper.

(The main steam header of the pumping station is directly opposite the hammer. It is feasible therefore to run a main from this header to the hammer, a distance of about 75 ft. This is satisfactory to the chief engineer of the pumping station.)

BRASS FOUNDRY, PIPE SHOP.

The machines in the brass foundry will require a 3 H.P. motor.

Cost of motor	$72.00.
The pipe shop requires a 2 H.P. motor — cost	63.00
Total	135.00

These machines are at present operated by motors (d.c.) furnished current which is generated locally.

Lights — We have allowed $160.00 for lighting this shop which is equivalent to 125 lamps taking 50 watts ~~cost~~ burning 3 hours per day. We feel this liberal, for a machine shop of this character.

Summation— A summation showing the estimated amount that can be saved annually if motor drive is used, is to be found in the conclusion of this study.

[illegible]
[illegible] OLOGY
[illegible]

WATER-PIPE-EXTENSION-SHOP

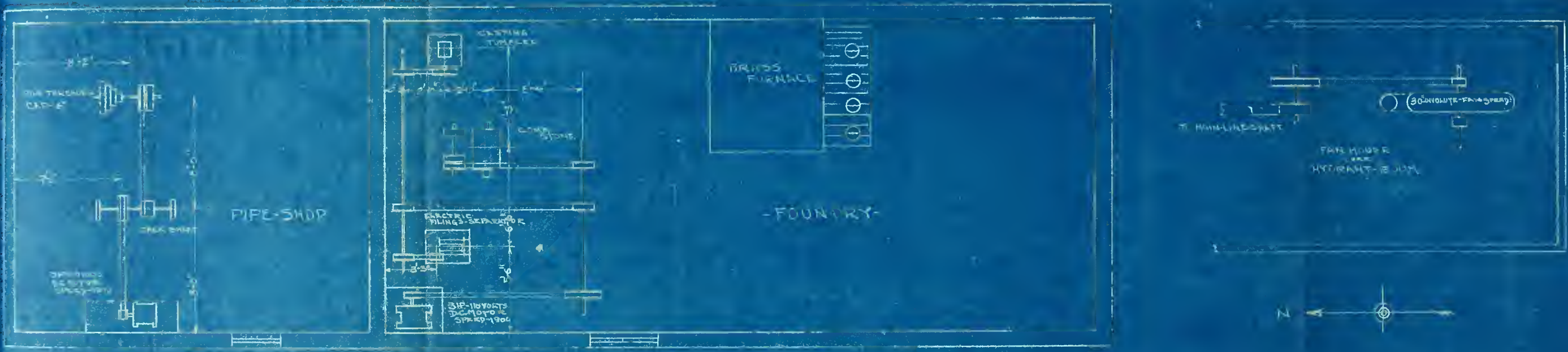
CITY OF CHICAGO

ASHLAND AND BLUE ISLAND AVE'S

PRESENT FOUNDRY-PIPE SHOP AND FAN HOUSE

AUG-8TH '08

SCALE 1/4" = 1 FT



POLICE DEPARTMENT

MACHINE SHOP

The machine tools of this shop consist of a 20 inch engine lathe, 16 inch drill press, 24 inch shaper and a hack saw, all driven from a line shaft which is belted to a 3-1/2 H.P. motor, operated from the "Chicago Edison System".

A combination buffer with exhaust blower has been purchased, which will be installed in the near future.

The test made here shows a belt transmission loss of .27 H.P. The cost of power is 3-1/2 cents per kilowatt hour. This loss in one year operating 8 hours per day, 5-1/2 days a week and 52 weeks per year amounts to $21.50.

At the Sanitary District's price per horse power hour the yearly loss will be so low that it will not warrant individual drive.

I recommend the continued use of the single phase motor which is driving these machines at present.

The combination buffer and blower which is to be installed will require a 3 H.P. motor. Cost	$72.00.

WOOD WORKING MACHINES AND BLACK SMITH SHOPS

These machines are driven by a 10 H.P. motor (direct current), all belted to one main line shaft. See floor plan drawing. In the wood working department, they consist of

1 - 36" Band Saw.

1-Horizontal Wood Drill

1 - Hub Boring Machine

1 - Vertical Drill Press

1 - 24" Sander (drum type).

POLICE-DEPARTMENT-SHOP

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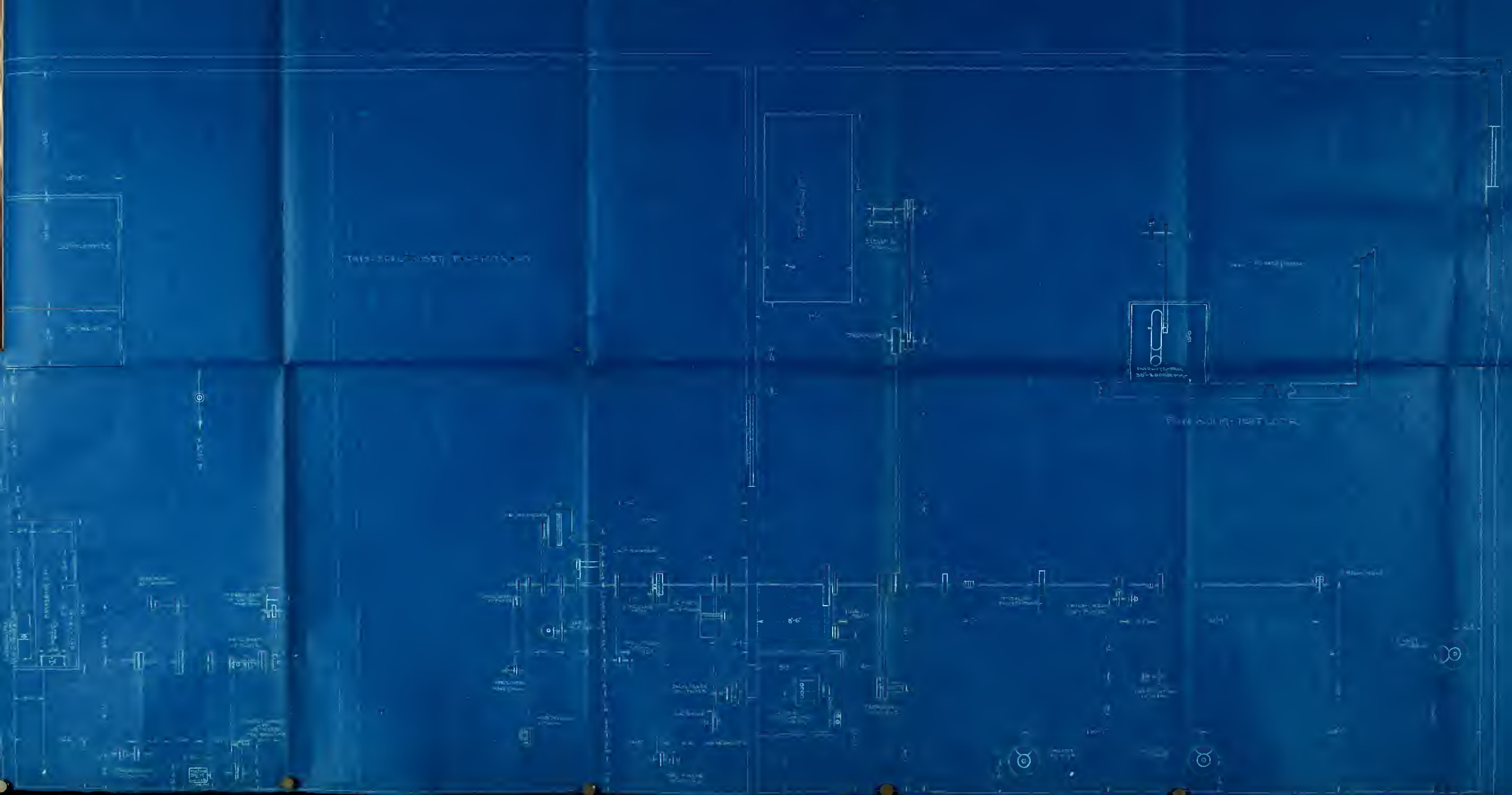


1 - 18" Circular Saw

1 - 12" Buzz Planer & Jointer

1 - 10" Wood Lathe

1 - 24" Grind Stone

The transmission losses in shafting and belts, determined by test, are 2.25 H.P.

This motor is run on a flat rate basis of $12.00 per month or $144.00 per year. When this rate was given by the Union Traction Company a 5 H.P. motor was operating. The larger motor was substituted, but no change of rate has been made.

In the wood shop of the Water Pipe Extension Department this company is charging the "City" 5 cents per k.w. hour; the motor being operated from the same line as the Police Shop. We may assume then that 5 cents per k.w. hour or ~~$~~3.73¢ per horse power hour as the intended charge.

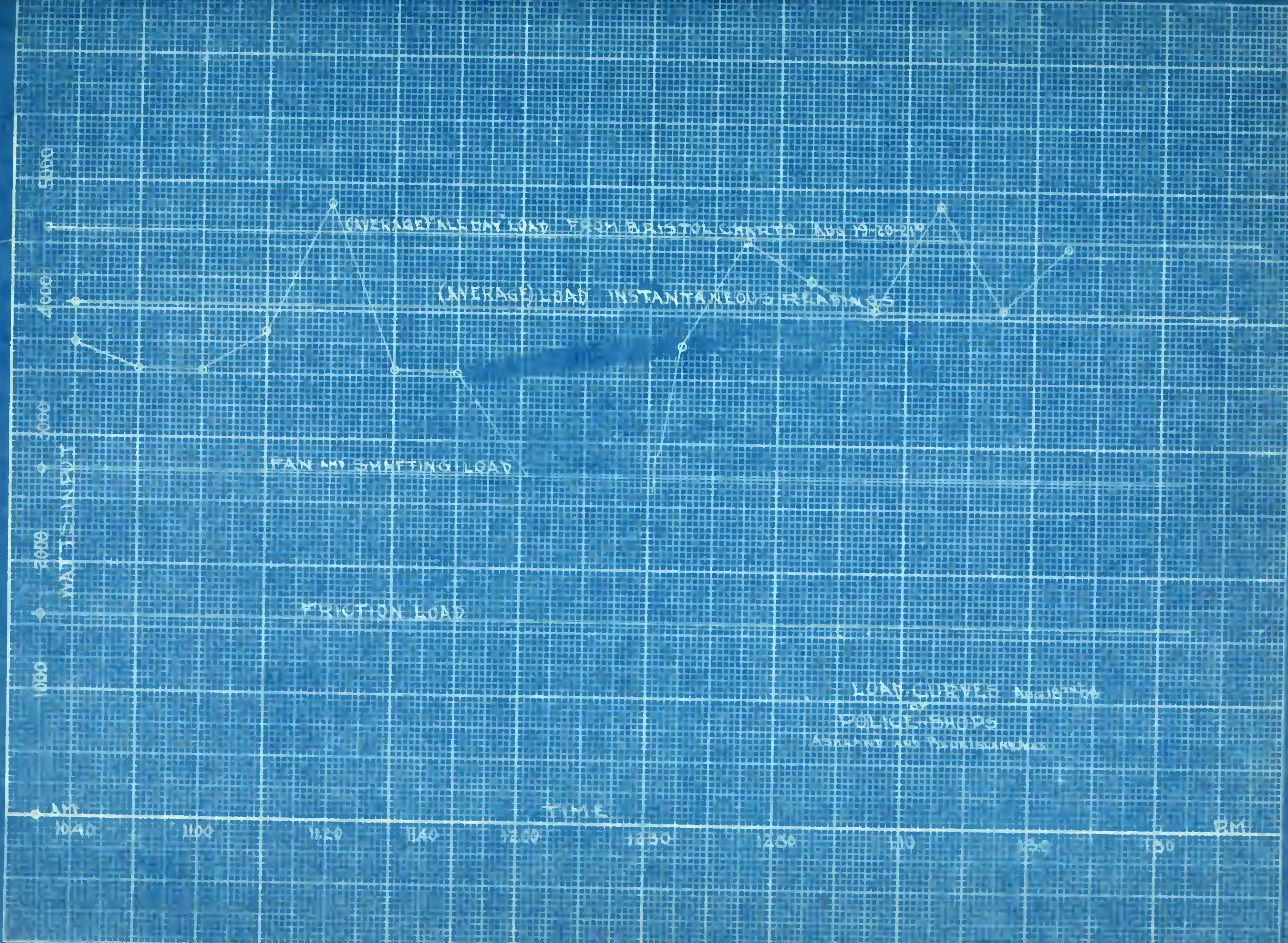
At this rate the loss in the shafting per year will amount to $190.10.

The working all-day load (attached hereto) on this motor was obtained by means of a recording instrument, which shows an average of 4620 watts. On the present flat rate basis the cost per horse power is only $1.20 and the transmission loss amounts to $52.40. This is cheaper than using Sanitary District power, but is due to the facts mentioned above.

OPERATING CONDITIONS

The machines in this shop are used very intermittently, the planer, band saw and sander being used the most. They will however never be in service simultaneously.

In order to eliminate the friction losses I recommend the



(AVERAGE) ALL DAY LOAD FROM BRISTOL CHARTS AUG 19-20-21
(AVERAGE) LOAD INSTANTANEOUS READINGS
FAN AND SHAFTING LOAD
FRICTION LOAD
LOAD CURVES No. 18
POLICE SHOPS
WATTS INPUT
5000
4000
3000
2000
1000
TIME
AM
10.40
11.00
11.20
11.40
12.00
12.20
12.40
1.00
1.20
1.40
PM

ARMOUR
INSTITUTE OF TECHNOLOGY
CHICAGO

installation on the

36" Band saw 12" Sander	a 3 H.P. motor — Cost	$72.00
18" Circular saw 12" Buzz planer	a 5 H.P. motor — cost	79.00
The rest of the machines on a 2 H.P. motor cost		63.00

Black Smith Shop

Patrol Elevator	3 H.P. motor cost	$72.00
Forge Blower	2 H.P. " "	63.00
Emery Stone	2 " " " "	63.00
Fire Bender 16" Drill Press Threading Machine	2 " " " "	63.00
Total		261.00

This makes a cost of $547.00 to equip the shop with motors as recommended.

The cost of power saved, estimated 80% of the loss amounts to $41.90 each year figured on the flat rate basis.

PRESENT OPERATING COSTS

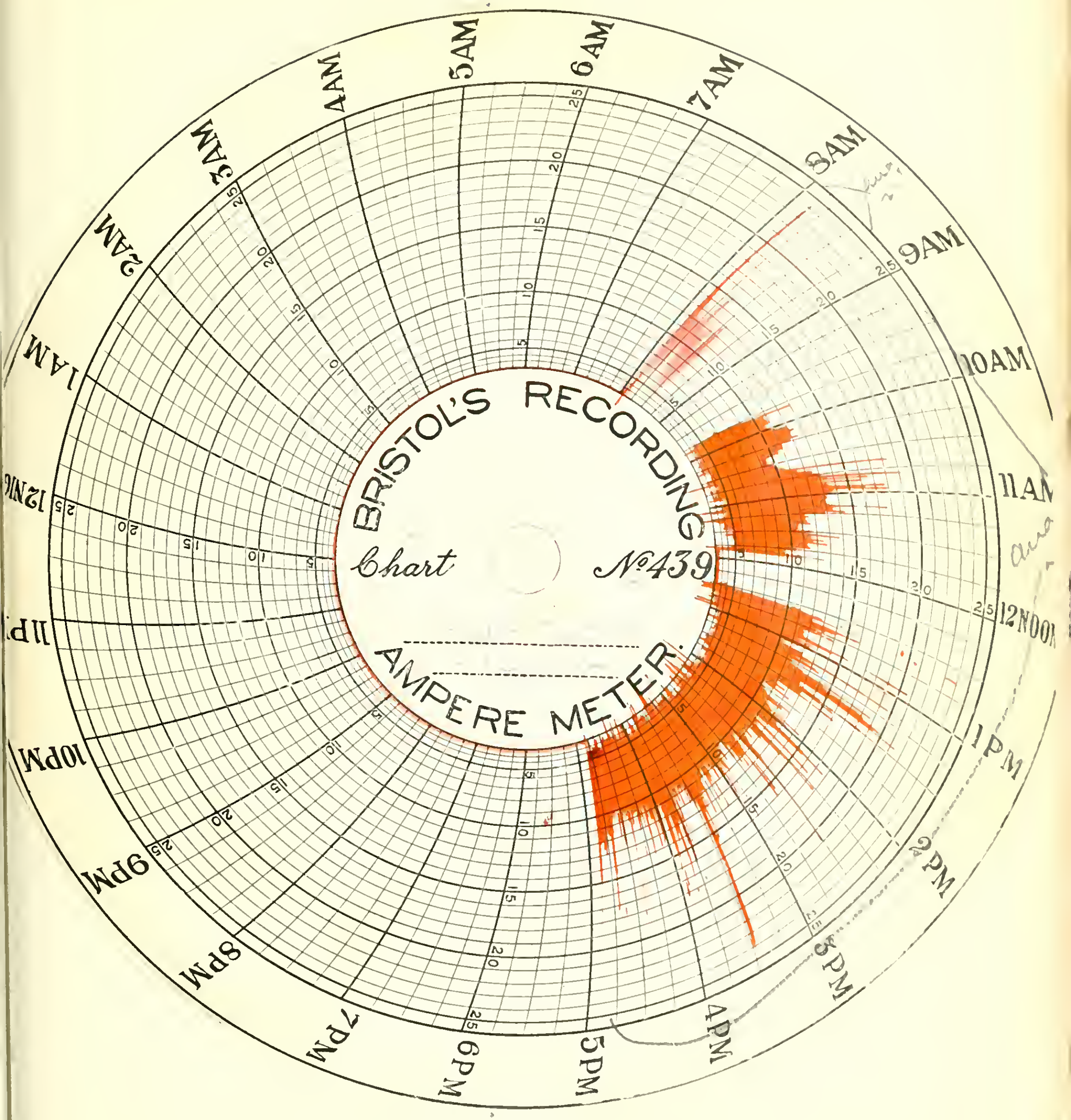
The yearly operating cost of this shop is

Chicago Edison Bills 1907	$372.98
Chicago Union Traction	144.00
Total	516.98

Cost of "Sanitary District" power if the same amount is used per year less the saving in friction losses pointed out above, will be $782.00.

From the above it is plainly seen that present operating

LOAD CURRENT



POLICE SHOP
10-H.P.-550 VOLT-MOTOR

MOTOR-TEST-MADE AT POLICE DEP'T SHOPS

WATTAGE INPUT-ON-$3\frac{1}{2}$ HP SINGLE PHASE MOTOR	WATTAGE REQUIRED TO DRIVE LOAD. NOT CORRECTED FOR VARIATION IN MOTOR EFF.

MOTOR-TEST-MADE AT POLICE DEP'T SHOPS

WATTAGE INPUT ON 3½ HP SINGLE PHASE MOTOR					WATTAGE REQUIRED TO DRIVE LOAD NOT CORRECTED FOR VARIATION IN MOTOR EFF.					
VOLTS	CURRN	WATTS	POWER FACTOR	REMARKS	MOTOR IDLE	SHAFT-ING	HACK SAW	DRILL PRESS	LATHE	SHAP-ER
221	12.4	716	26	HACK SAW AND SHAFTING SAW TAKING MAXIMUM CUT			124			
223.5	13.05	950	32.3	DRILL PRESS AND SHAFTING 13/16" DRILL-CUTTING 1" STEEL PLATE				748		
223.5	12.95	840	29.05	LATHE AND SHAFTING TESTED WITH 1¼" STEEL ROD ⅛" CUT					638	
223.5	15.2	1230	36.2	SHAPER – AND – SHAFTING 1"X12"X4½" STEEL PLATE – 12" STROKE ⅛" CUT						1028
223	12.15	615	22.8	SHAFTING		202				
224	12.4	716	26.0	HACK SAW AND SHAFTING			124			
223.5	15.2	1230	36.2	SHAPER AND SHAFTING (MAX. CUT)						1028
221	17.2	1870	49.4	DRILL PRESS – LATHE – SHAPER – HACK-SAW AND SHAFTING (MAX. LOAD)						
228	14.5	1275	38.8	SHAPER AND SHAFTING						1073
228	12.5	816	28.5	LATHE AND SHAFTING				629	614	
228	12.52	995	35.0	DRILL PRESS – HACK-SAW – SHAFTING						
231	12.5	425	14.8	MOTOR ALONE	425					
230	14.0	402	12.5	MOTOR ALONE	402					
228	14.8	592	17.5	MOTOR AND SHAFTING		179				

WATTAGE INPUT ON 10 HP 550 – VOLT MOTOR –				WATTAGE-REQUIRED TO DRIVE LOAD (NOT CORRECTED FOR VARIATION IN MOTOR "EFF")																	
VOLTS	CURRENT	WATTS	REMARKS	MOTOR	SHAFT	CIRC SAW	BAND SAW	JOINTER	SANDER	MORTISE MACH	EMERY WHEEL	TIRE BENDER	PATROL ELEVAT.	FAN (FORGE)							
537	1.75	940	MOTOR ALONE	940										1145							
531	7.00	3760	SHAFTING-AND-FAN		1675																
533	10.0	5330	2" HICKORY – 6' – CUT CIRCULAR SAW SHAFTING – FAN			1800															
544	8.4	4570	BAND SAW – SHAFT'G FAN 2" WHITE OAK				1040														
535	9.4	5050	JOINTER – FAN SHAFTING 1½"X5" W-OAK 3/16" CUT					1520													
542	8.4	4550	SANDER – FAN SHAFTING 16" HARD MAPLE						1020												
533	8.9	4745	" " "						1215												
544	7.0	3810	MORTISE MACH FAN – SHAFTING							280											
546	8.9	4870	SHAFTING EMERY WHEEL – FAN GRINDING CASTING								1340										
546	7.5	4100	MORTISE MACHINE FAN – SHAFTING							570											
544	8.4	4570	BANDSAW FAN SHAFTING				1040														
544	7.5	4100	TIRE BENDER FAN · SHAFT 3×½×¾ U									570									
544	10.8	5875	ELEVATOR – FAN SHAFT (PATROL-WAGON)										2345								
544	6.5	3530	SHAFTING FAN											1145							
544	4.6	2500	SHAFTING		1560																

costs cannot be reduced by a rearrangement of the shop, installing motors for individual drive as outlined and the utilization of Sanitary District power. It is advisable, however, to make the change, because of the fact that the Union Traction power, coming from a trolley line is unreliable, dangerous and not in accordance with the rules and regulations of the "Board of Fire Underwriters." The Edison power used is more expensive than the Sanitary power.

WATER PIPE DEPARTMENT

WOOD SHOP AND SAW MILL

The transmission losses in this shop from test were found to be .95 H.P.

The machinery is operated but a fraction of the day and consequently the yearly loss can not be accurately determined. It is very seldom that more than one machine is used at once. We estimate the friction loss to amount to about 40% of the load. The yearly cost of operation for 1907 was $123.50 which makes $49.40 yearly loss to the "City."

MOTOR EQUIPMENT

With individual motor drive and utilization of "Sanitary District" power, transmission losses will be saved and the cost much less.

I recommend the following installation on the

36" Band saw	2 H.P. motor cost	$63.00
24" Swing saw	3 " " " "	72.00
18" Rip saw	2 " " " "	63.00
24" Wood lathe Saw Sharpener & Emery	2 H.P." "	63.00
Total		261.00

THE-WOOD-SHOP OF WATER PIPE EXT DEPT

BLUE-ISLAND AND ASHLAND AVE'S AUG 22ND 08

WATTAGE INPUT ON 15 HP 550-MOTOR				WATTS REQ'D-TO-DRIVE-LOAD NOT CORRECTED FOR MOTOR EFF.					
VOLTS	CURRENT	WATTS	REMARKS	MOTOR	SHAFTNG	BAND SAW	WOOD LATHE	RIP SAW	SWING SAW
533	3.3	1792	MOTOR AND SHAFTING		702				
537	2.0	1090	MOTOR ALONE	1090					
546	5.2	2840	WOOD LATHE AND SHAFTING (GEORGIA PINE PLUG)				1048		
537	14.0	7510	BAND-SAW-RIPSAW-SWING SAW SHAFTING (3"x12" OAK)						
557	6.0	3350	BAND SAW AND SHAFTING (3"x12" OAK)			1558			
557	7.0	3910	SWING-SAW, SHAFTING (3"x12" OAK)						2118
546	6.0	3280	RIP SAW ~ SHAFTING 3"x3" (GEORGIA PINE)					1488	

[illegible]
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[illegible]

WOOD-SHOP

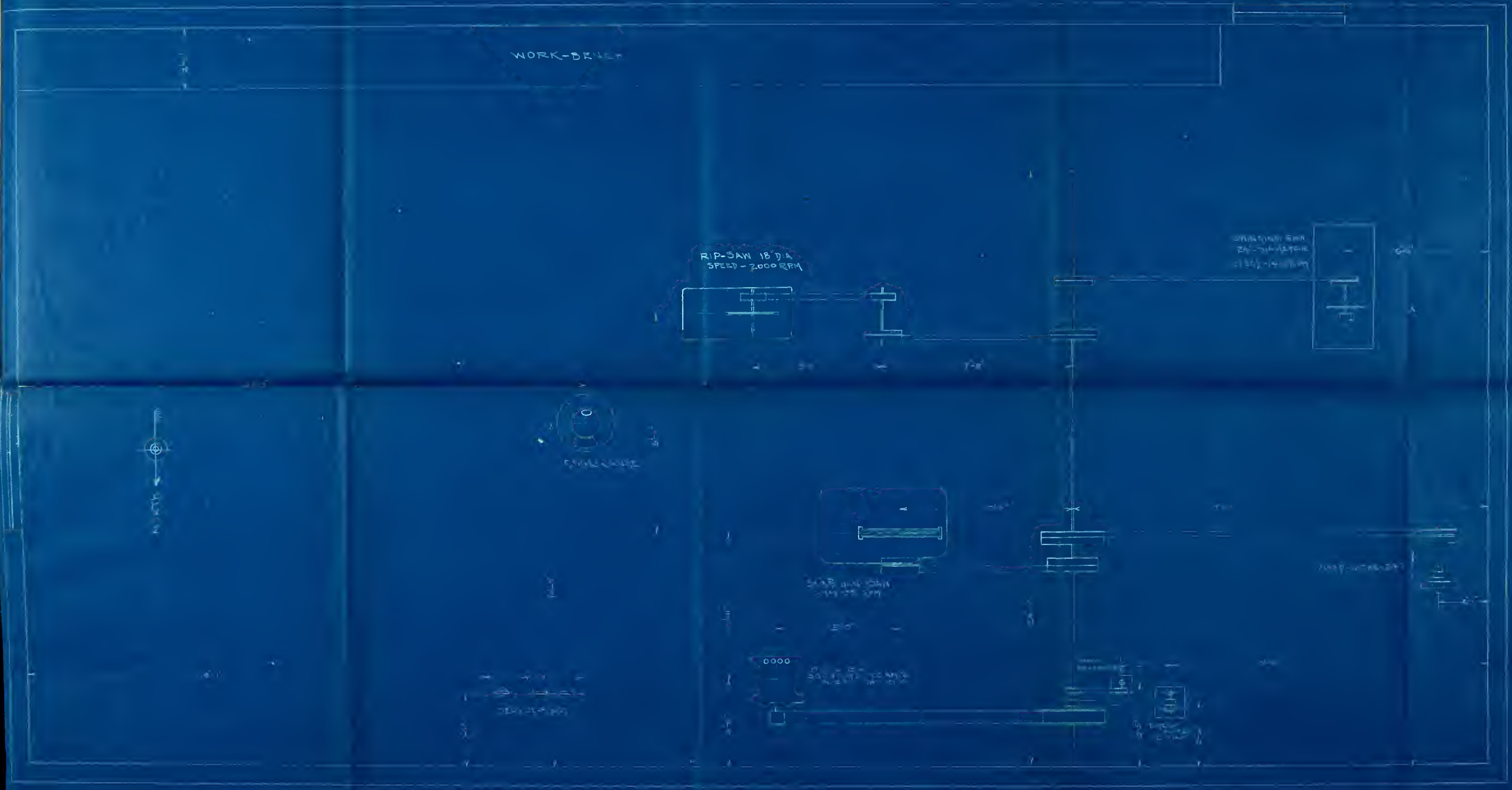
WATER PIPE EXTENSION DEPARTMENT

CITY OF CHICAGO

[illegible]

PRESENT LOCATION OF MACHINES

[illegible] SCALE ½" = 1 FT



SERVICE

In order to get the "Sanitary District" power to the motors it will be necessary to make transformer installation and also cable from Blue Island Ave. and 22nd St., (where their lines now terminate) to the shops, a distance of 816'.

The cost of 3 - 30 k.v.a. - single phase 60v. 1200 to 2300 volts self coiled oil insulated transformers, delivered, -at $322.24 each is $968.52. 3 single phase 60v 2300 to 115-230 volt 30 k.v.a. self cooled oil insulated transformers will cost $703.95.

TRANSFORMER ROOM

A fire proof transformer room will have to be built in the Water Pipe Shop, in the present engine room. The estimated cost of this is $200.00.

Cable and Ducts

The cost of the cables and ducts from Blue Island Ave. to the shops is 816' x $1.785 = $1457.00.

COST OF TRANSMISSION LINE

The portion of the cost of constructing the transmission line from which these shops will be supplied chargeable to the shops, is assfollows:

This line extends from the Sanitary District sub-station at 31st St. and Western Ave. to 22nd St. and Blue Island Ave.

It is carried underground from Western Ave. and 31st St. to Claremont and Blue Island Ave. a distance of 3100 ft.

This type of construction cost us $1.785 per duct foot with cable pulled in and jointed up.

The cable is a three conductor #2/0 varnish cloth insu-

lated with lead covering. The insulation is guaranteed for 15000 volts operation.

The total load carried on this transmission line is 1609 k.v.a. The amount carried for the use of these shops is 90 k.v.a. estimated. Consequently, the charge to be made to this installation will be as shown in the following calculations:

$$3100' \times \$1.785 \times \frac{90}{1609} = \$309.40$$

Wood St. and Blue Island to Ashland Av. and Blue Island Av.

$$1475' \times \$1.785 \times \frac{90}{1609} = \$147.20$$

Cost of Aerial work from Blue Island Av. and Wood St. to Claremont and Blue Island Aves.

$$4000' \times \$1.05 \times \frac{90}{1609} = \$234.90.$$

Proportion of cost of tunnels chargeable to shops

Illinois & Michigan Canal	$24365.38
Under River at Western Av.	11816.35
	36181.73

$$\frac{36181.73}{12} \times \frac{90}{1609} = \$168.50$$

There are twelve ducts provided in these tunnels. We are using one. These figures we obtained from the annual report of 1907 of the Department of Electricity.

ESTIMATED COST MATERIAL AND LABOR

Water Pipe Extension Department Machine Shop

Material – 1030' - 1/2 Conduit	$56.30
975' - 3/4 "	72.00
630' - 1-1/2 "	78.00
2870' - #14 D.B.R.C. Wire	27.60
2055' - #12 " " " " "	20.50
	254.40

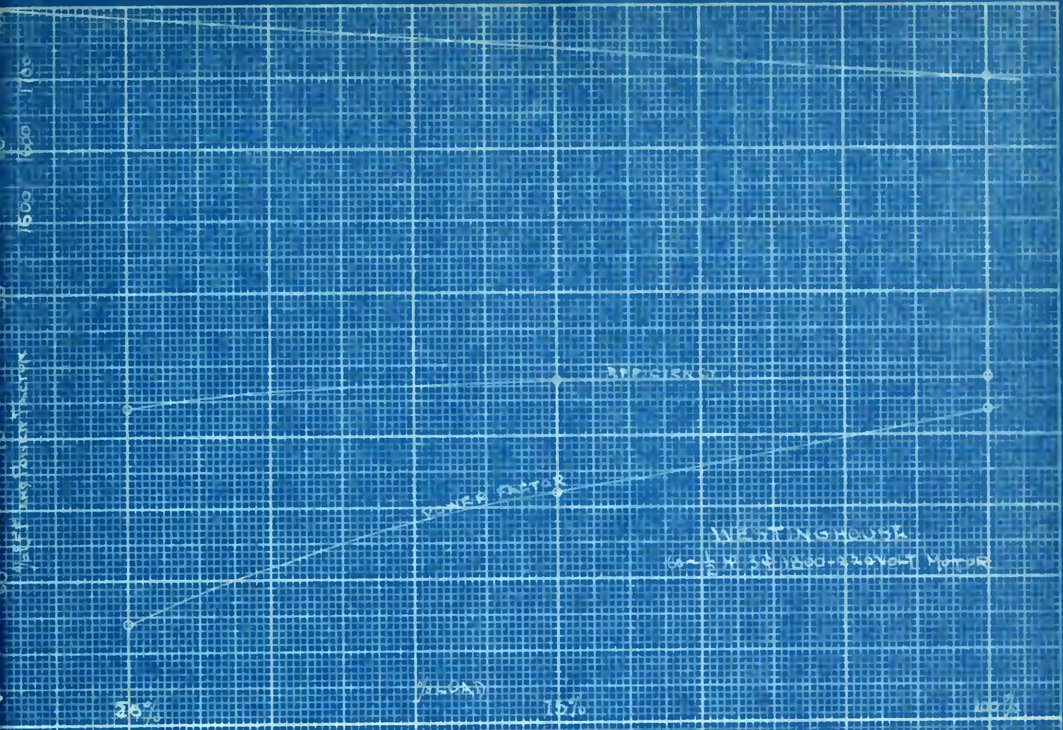
Forward	$254.40
300' - #6 D.B.R.C. Wire	7.80
330' - #4 " " " " "	11.65
Service Board and Miscellaneous Material	226.15
Labor 10 men 20 days at $5.00 per day	1000.00
Total	1500.00
Police Shop -	
2050' - #14 D.B.R.C. Wire	16.50
750(- #12 " " "" "	7.55
200' - #10 " " "" "	3.60
600' - 1/2 " " "" Conduit	33.78
Miscellaneous Material	288.57
Labor	500.00
Total	850.00
Water Pipe Yards	
Saw Mill Material ad Labor	$500.00

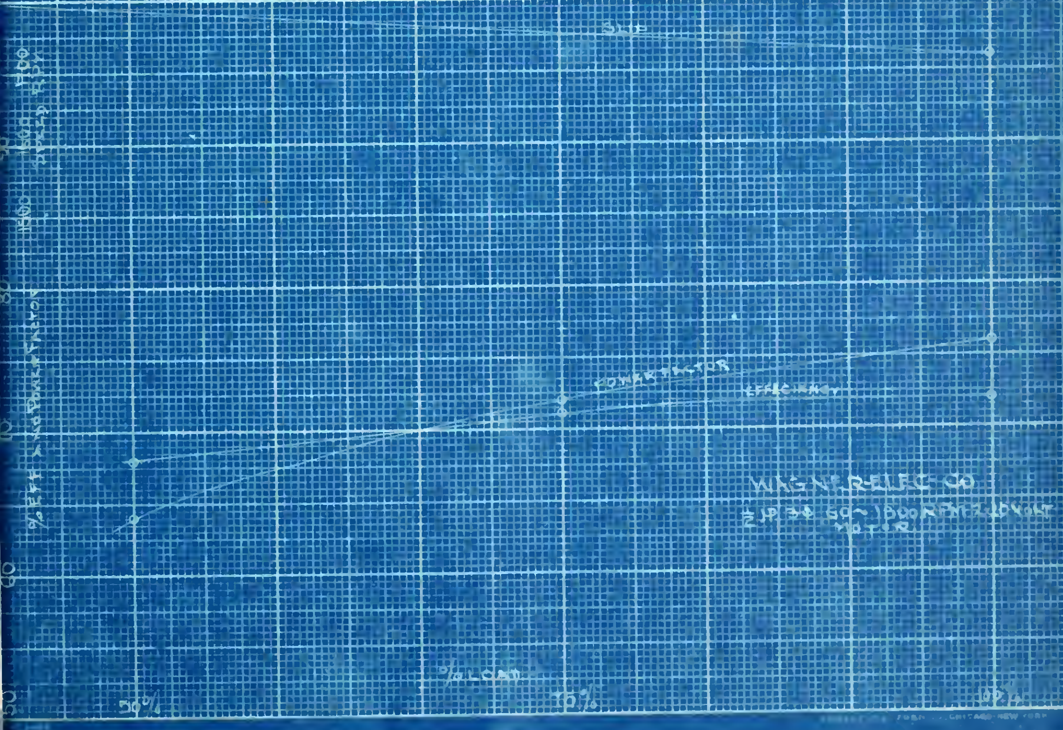
MOTOR CHARACTERISTICS

Attached hereto are motor characteristic curves on motors from 1/2 horse power to 20 horse power capacity. An examination of these will show that the motors of the various leading Mnfgr's. have practically the same characteristics. Consequently I am unable to recommend the adoption of any particular manufacturer's product. This will have to be determined by bid and delivery.

SUMMATION

Attached hereto in tabulated form is to be found a summary expressing in dollars and cents the conclusions I have drawn in this study; which are based primarily on data obtained from actual test, and partly on assumptions made from standard "American" practice.


1500 1600 1700
% EFF AND POWER FACTOR
EFFICIENCY
POWER FACTOR
WESTINGHOUSE
60~ 1/2 H.P. 3Φ 1800-220 VOLT MOTOR
% LOAD
25%
75%
100%


1500 1600 1700
SPEED R.P.M.
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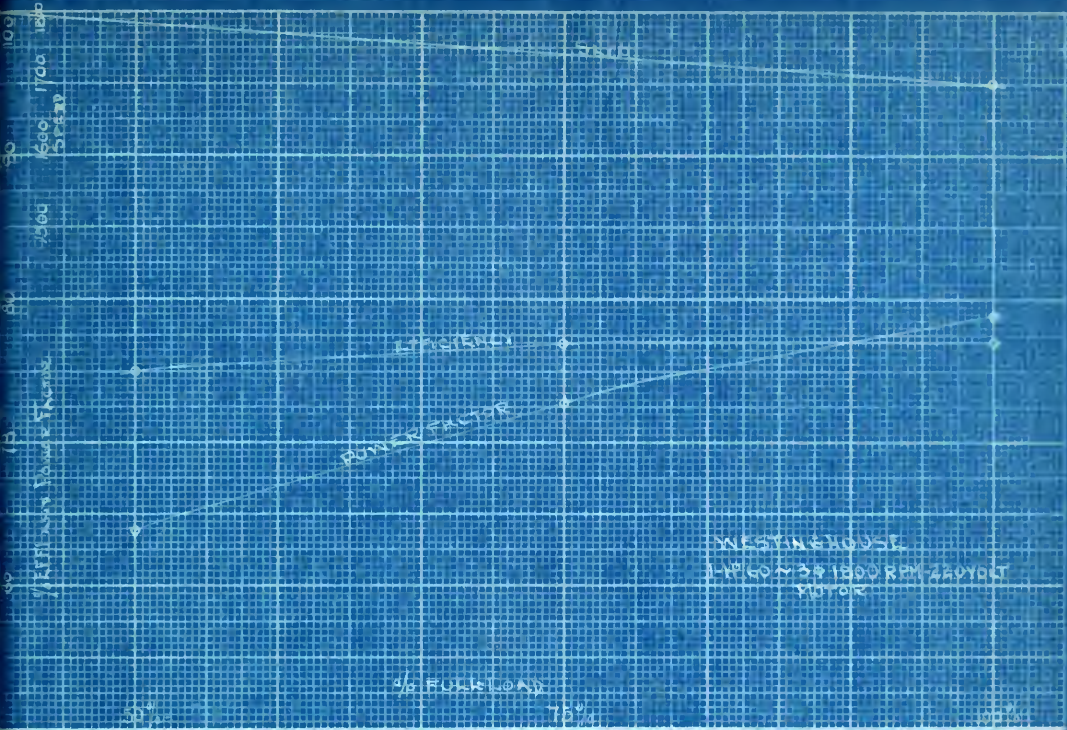
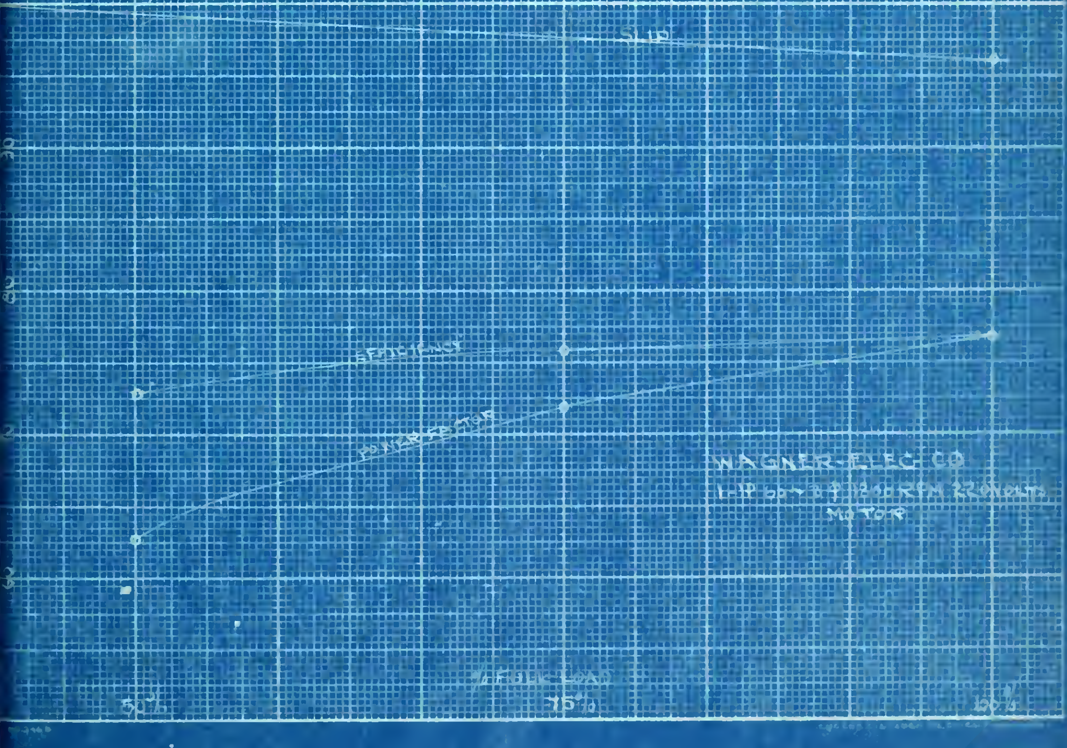
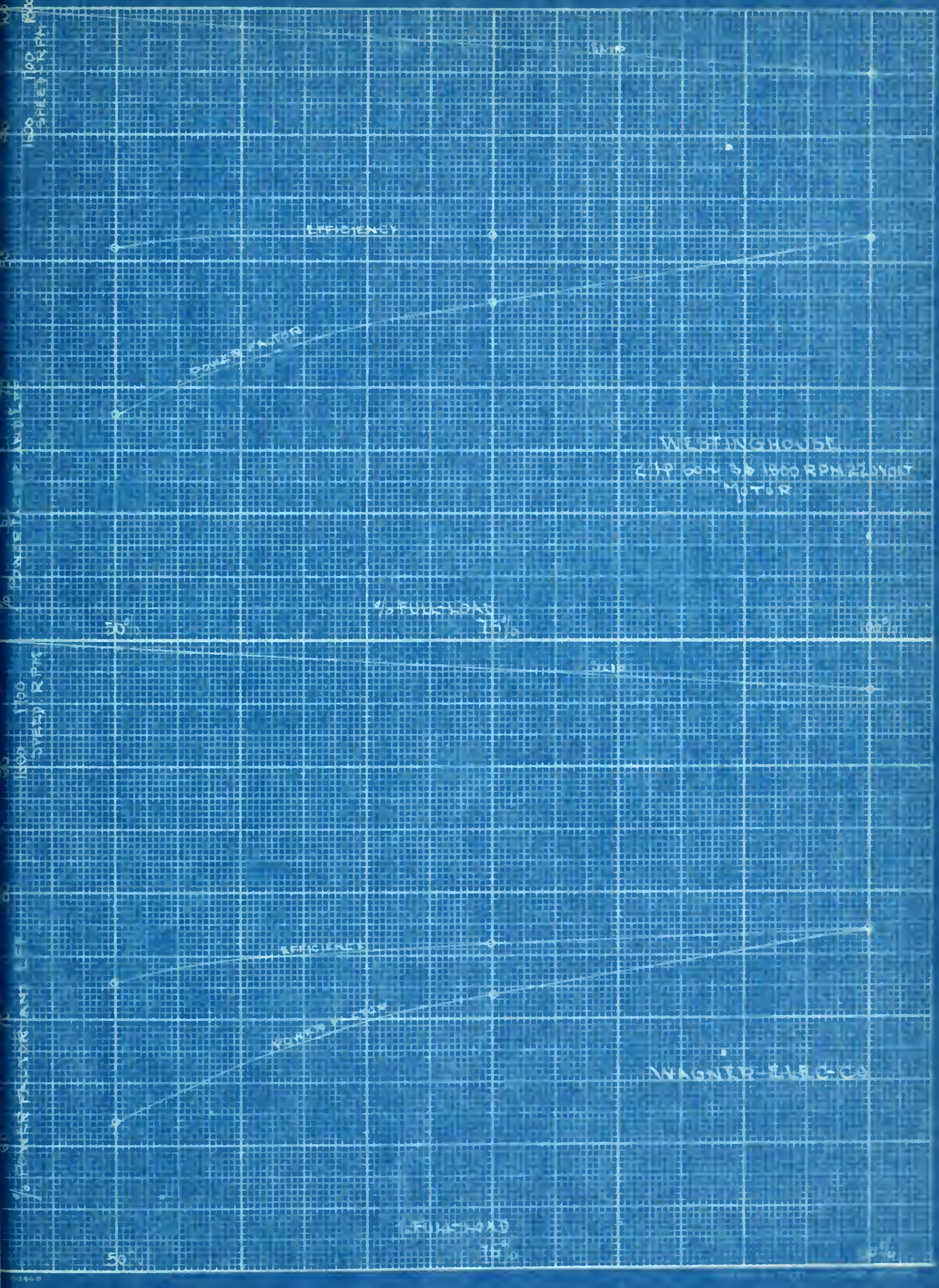
SLIP
POWER FACTOR
EFFICIENCY
WAGNER ELEC. CO.
1/2 HP 3Φ 60~ 1800 R.P.M. 220 VOLT
MOTOR
% LOAD
25%
75%
100%



100
90
80
70
60
1600 1700 1800
Speed
% Efficiency and Power Factor
Speed
Efficiency
Power Factor
WESTINGHOUSE
1-HP 60~3Φ 1800 RPM 220 VOLT
MOTOR
% Full Load
50%
75%
100%



Slip
90
80
70
60
Efficiency
Power Factor
WAGNER ELEC. CO.
1-HP 60~3Φ 1800 RPM 220 VOLT
MOTOR
% Full Load
50%
75%
100%


1600 1700 1800
SPEED R.P.M.
SLIP
EFFICIENCY
POWER FACTOR
WESTINGHOUSE
2 H.P. 60~ 3Ph 1800 RPM 220 VOLT
MOTOR
% FULL LOAD
50%
75%
100%
% POWER FACTOR AND EFFICIENCY
1600 1700
SPEED R.P.M.
SLIP
EFFICIENCY
POWER FACTOR
WAGNER ELEC. CO.
% FULL LOAD
50%
75%
100%

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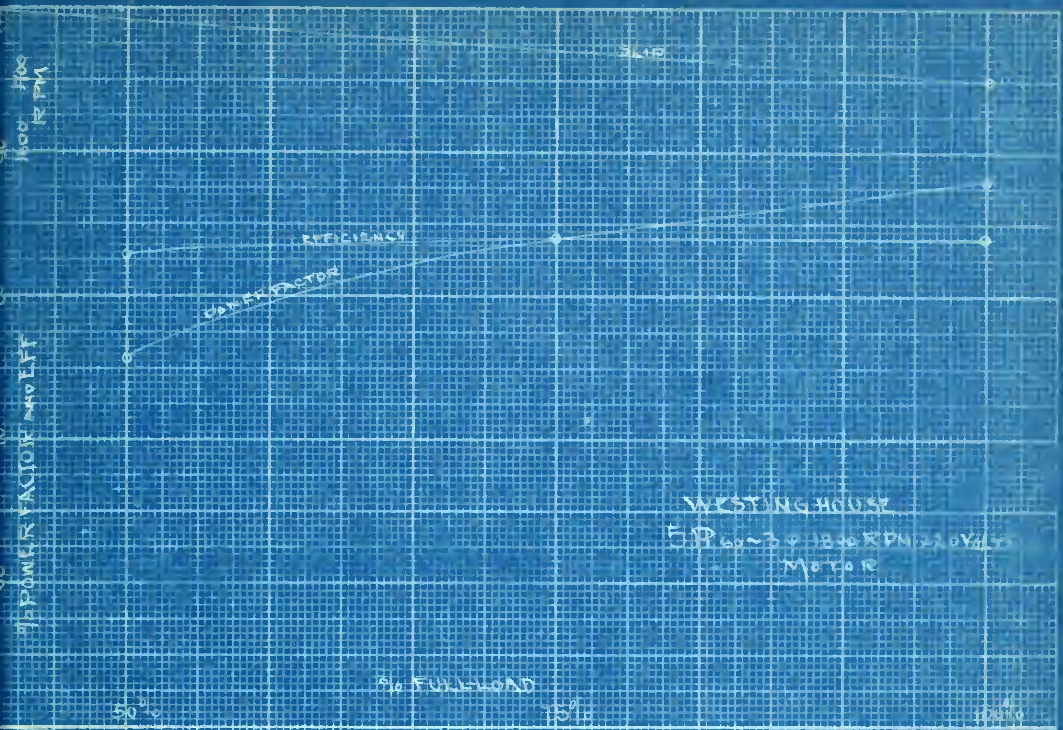
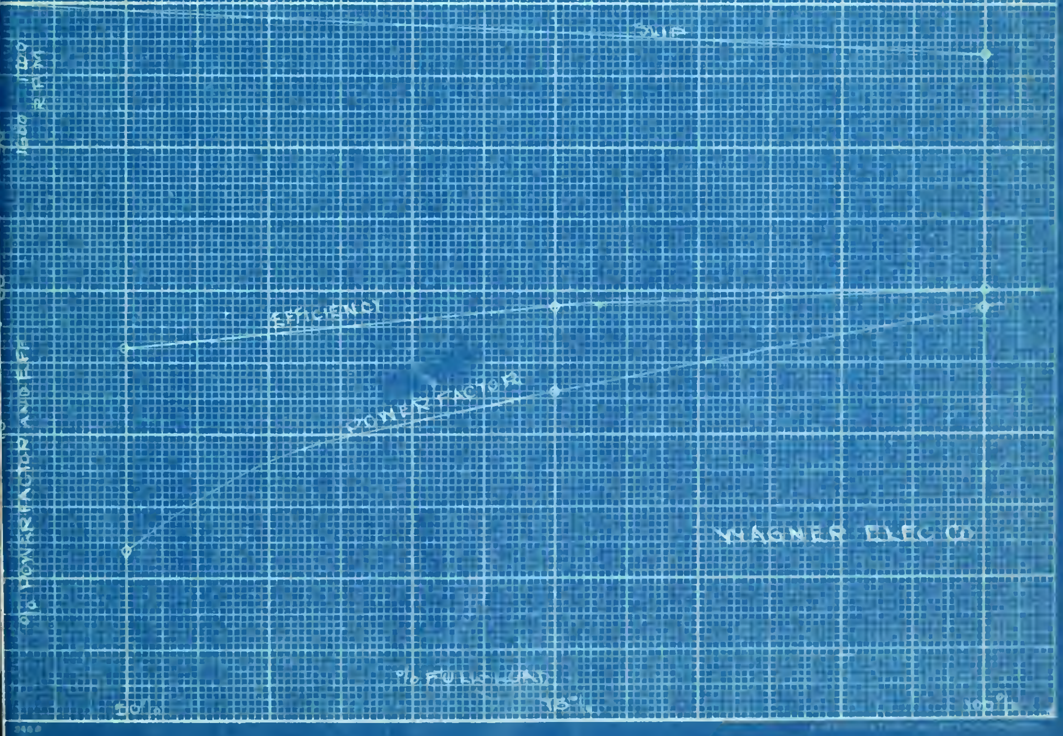
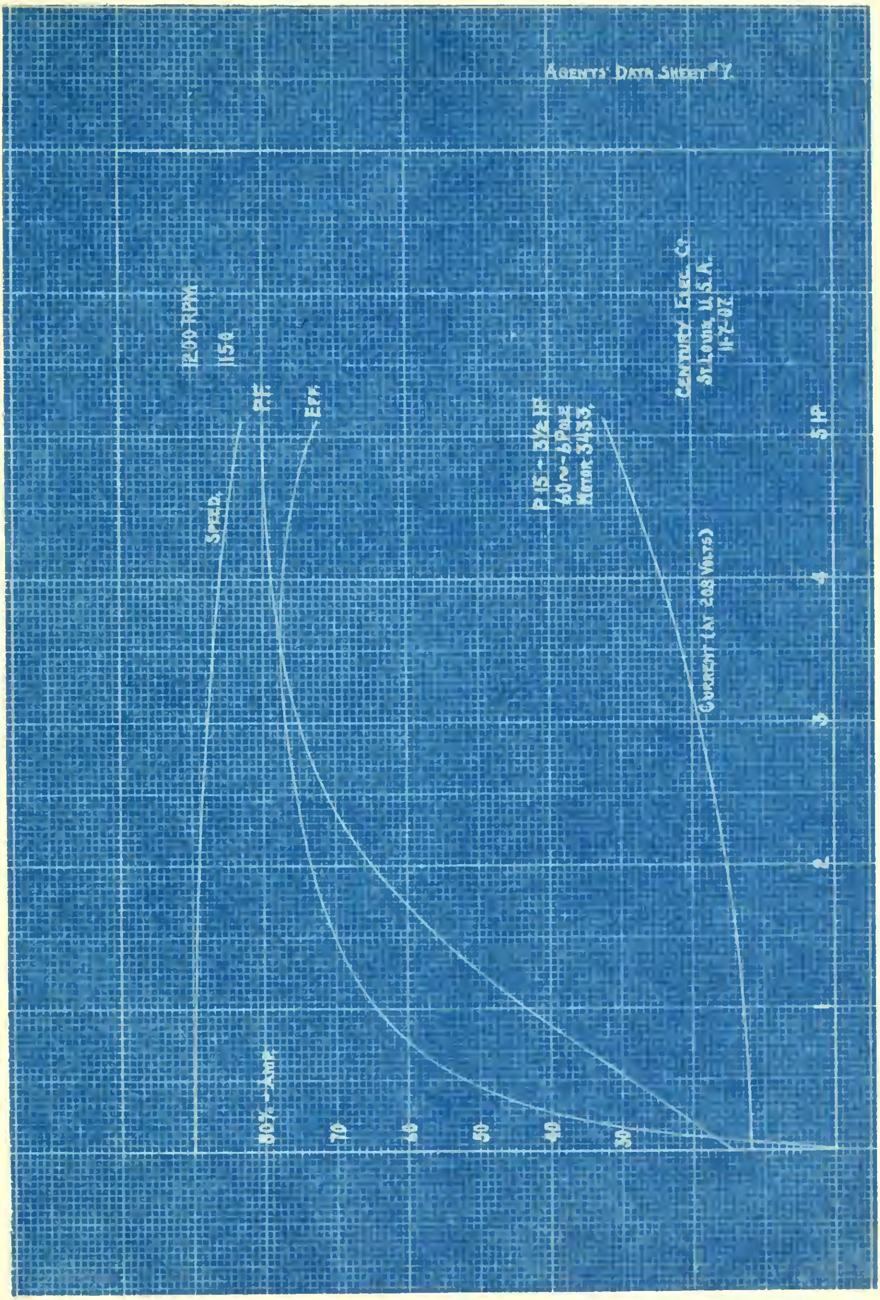


WESTINGHOUSE
5 HP 60~ 3φ 1800 RPM 220 VOLTS
MOTOR
SLIP
EFFICIENCY
POWER FACTOR
% POWER FACTOR AND EFF
1600 1700 RPM
% FULL LOAD
50%
75%
100%



WAGNER ELEC CO
SLIP
EFFICIENCY
POWER FACTOR
% POWER FACTOR AND EFF
1600 1700 RPM
% FULL LOAD
50%
75%
100%


Agents' Data Sheet #7
1200 RPM
115A
Speed.
P.F.
Eff.
P.15 – 3½ HP
60~ – 6 Pole
Motor 3433.
Century Elec. Co.
St. Louis, U.S.A.
1-7-07
Current (at 208 Volts)
80% – Amp
70
60
50
40
30
1
2
3
4
5 HP

An examination of this data will show that after all motors have been installed and in operation there will be an estimated saving of 57.5% transmission friction losses, which if expressed in money, amounts to $815.53 per year at the present cost of power. This will raise the total *operating efficiency of the shops to 62.6% which I believe will compare quite favorably with the most efficient shops to be found in our "City".

In ascertaining the cost of power per year with the "Sanitary District" source the following factors were considered, viz., losses in transmission friction, losses in motors and losses in the transformers to which was added the cost of the net load, (this load being found from the test). The transmission line losses were so extremely small that they were not considered.

Each shop was considered separately because they are maintained and operated by different departments and consequently must be paid from the appropriations of that particular department. In this way the amount chargeable to each department may be found in the table.

Machine Shop Water Pipe Extension Department -

The estimated expenses viz, the cost of motors, transformers installation, (including labor and material) cable and ducts from 22nd St. to the shop, portion of cost of transmission line chargeable, portion of cost of tunnels under the river and canal amounted to $5362.20 to make the charge.

As a yearly expense we must carry interest at 4% on the

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*By operating efficiency is meant the ratio of the cost of useful power to the cost of useful power plus the belt friction and motor losses.

cost of making the change, maintenance at 4% on the investment, provide a sinking fund, (8% of the cost of making the change) drawing interest at 4% compounded, which will allow a complete rehabilitation at the end of ten years; which I estimate to be the life of this equipment, and then pay for the power used which totals $2317.10

The present yearly expenses namely the cost of power and maintenance is $3624.40.

This shows a net yearly saving of $1307.30 and certainly is worth consideration.

Police Shop - The cost of installing motor drive estimated at $2454.82

Yearly expenses to be carried with motor drive 1174.76

Present yearly cost of operation 841.98

Saw Mill - Water Pipe Department

Cost of making change - - - - - $1131.65

Yearly expenses to be carried with motor drive $239.30.

Present yearly cost - - - - - - - - -$ 273.50

This shows a sum total yearly saving of $1008.72 in the operation of all the shops with "Sanitary District" power, over the present method of operation.

I have not given a valuation to the steam engine, and D.C. motors which will be replaced, by the A.C. motors. There will also be quite a few pulleys (iron) and steel shafting thrown out of service on which may be placed a valuation.

I didn't consider it necessary to value this material to show that it is highly advisable to change to motor drive. A saving

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The cost of operation has been omitted because this expense will be the same as at present.

of 24.6%of the present yearly cost of operation with an expenditure of only $8948.67 is the main item of consideration.

Flexibility in Operation-

The re~~habilitation~~liability of continuous service from the "Sanitary District System" is as good if not better than the present drive, and besides this an element of flexibility will be present which is not the case now. If a machine or belt breaks with the present method of operation it is necessary to close down the entire shop until repairs are made. With motor drive however, the motor driving the particular machine or section in which the damage occurs may be stopped without affecting the rest of the shop.

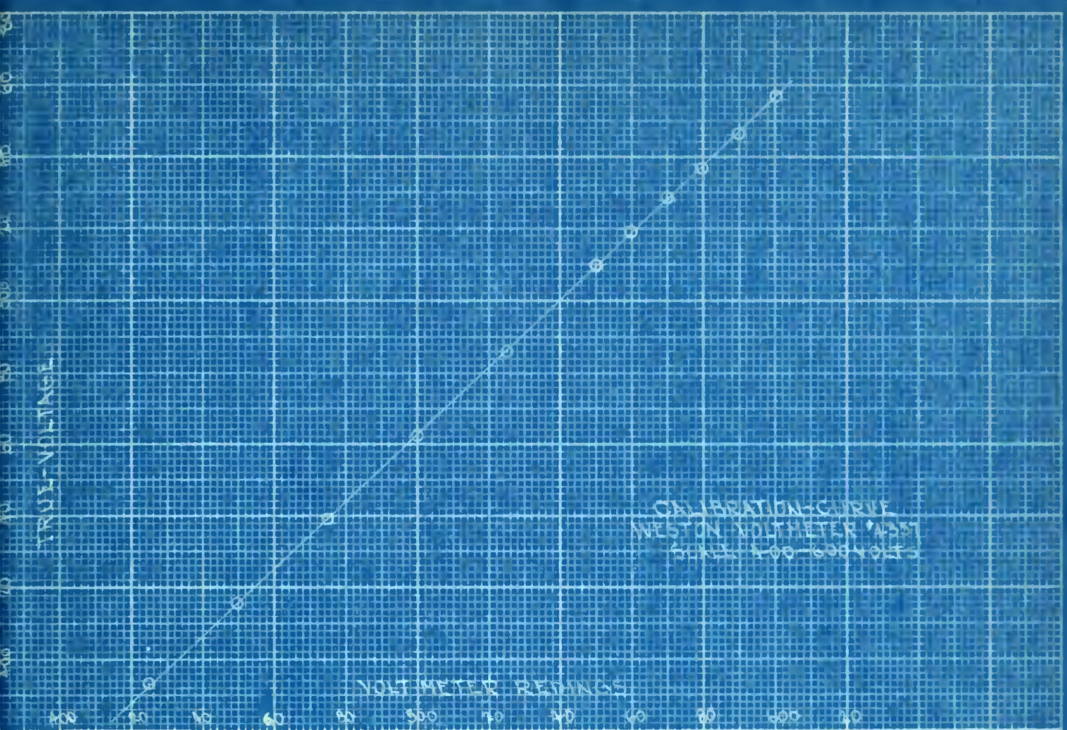
If motor drive is adopted it will be necessary to lay out a conduit and wiring diagram, locate motors and controllers, design platforms to contain the machines and specify how the installation is to be made.

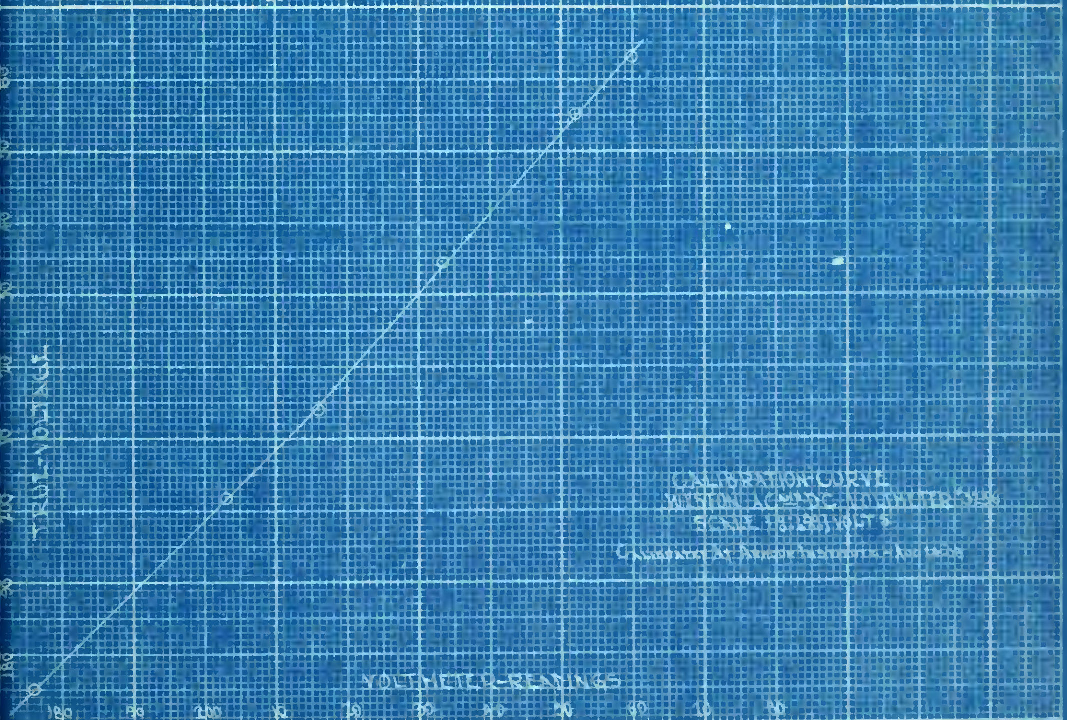
From the figures I submit herewith it is readily seen that motor drive is advisable and I strongly recommend it.

APPENDIX

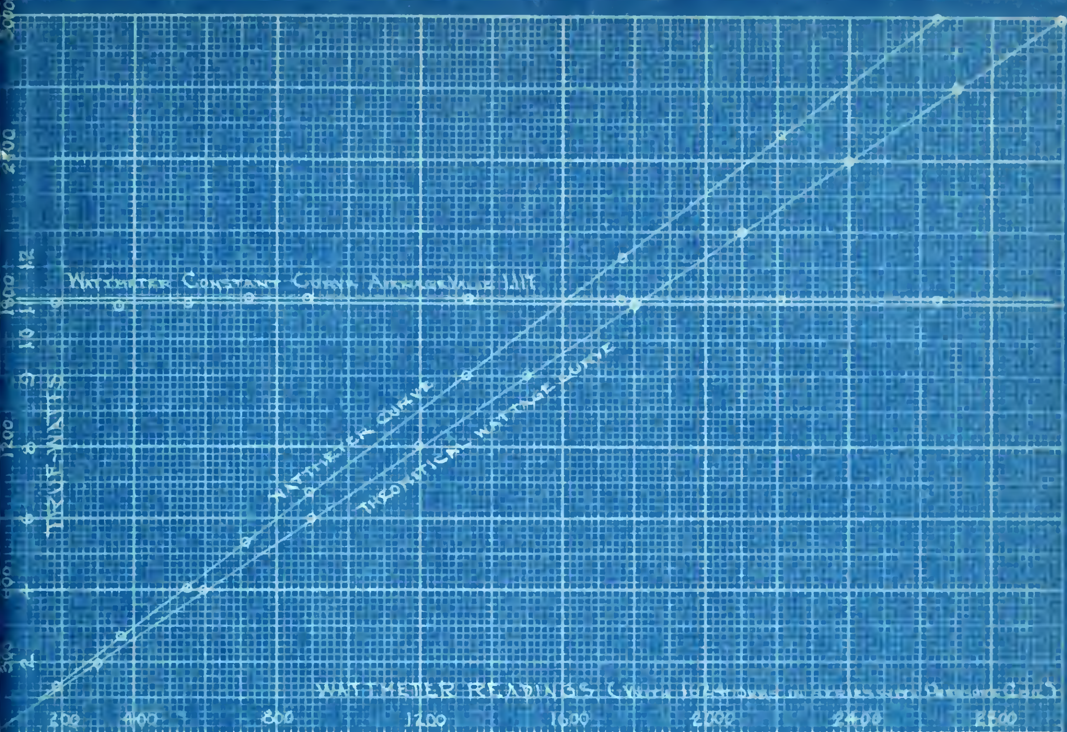
Heating - The Water Pipe Extension and the Police Shops are heated by steam from the pumping station. They are charged for two tons of coal per day for six months of the year. With coal at $2.60 per ton makes a cost of $1716.00 each year for heating these shops. If the motors are installed we would recommend the installation of a low pressure boiler for heating; and placing the motor attendant in charge of the same.

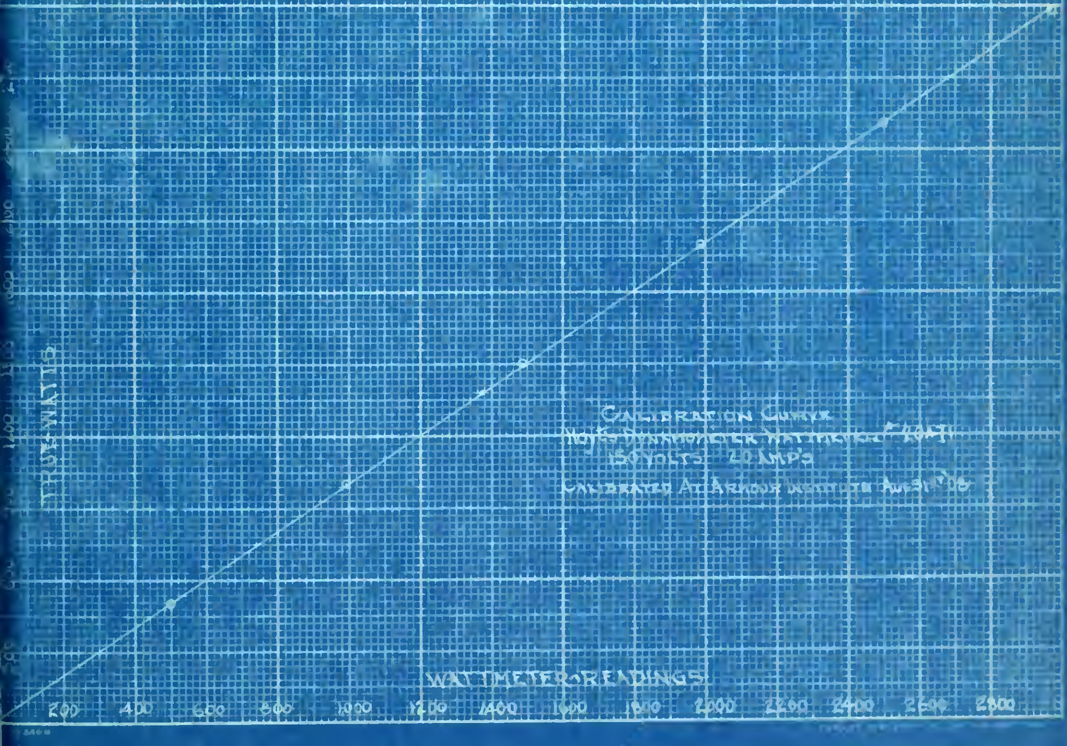
This we believe can be done at a very low figure and money saved over the present cost of heating.

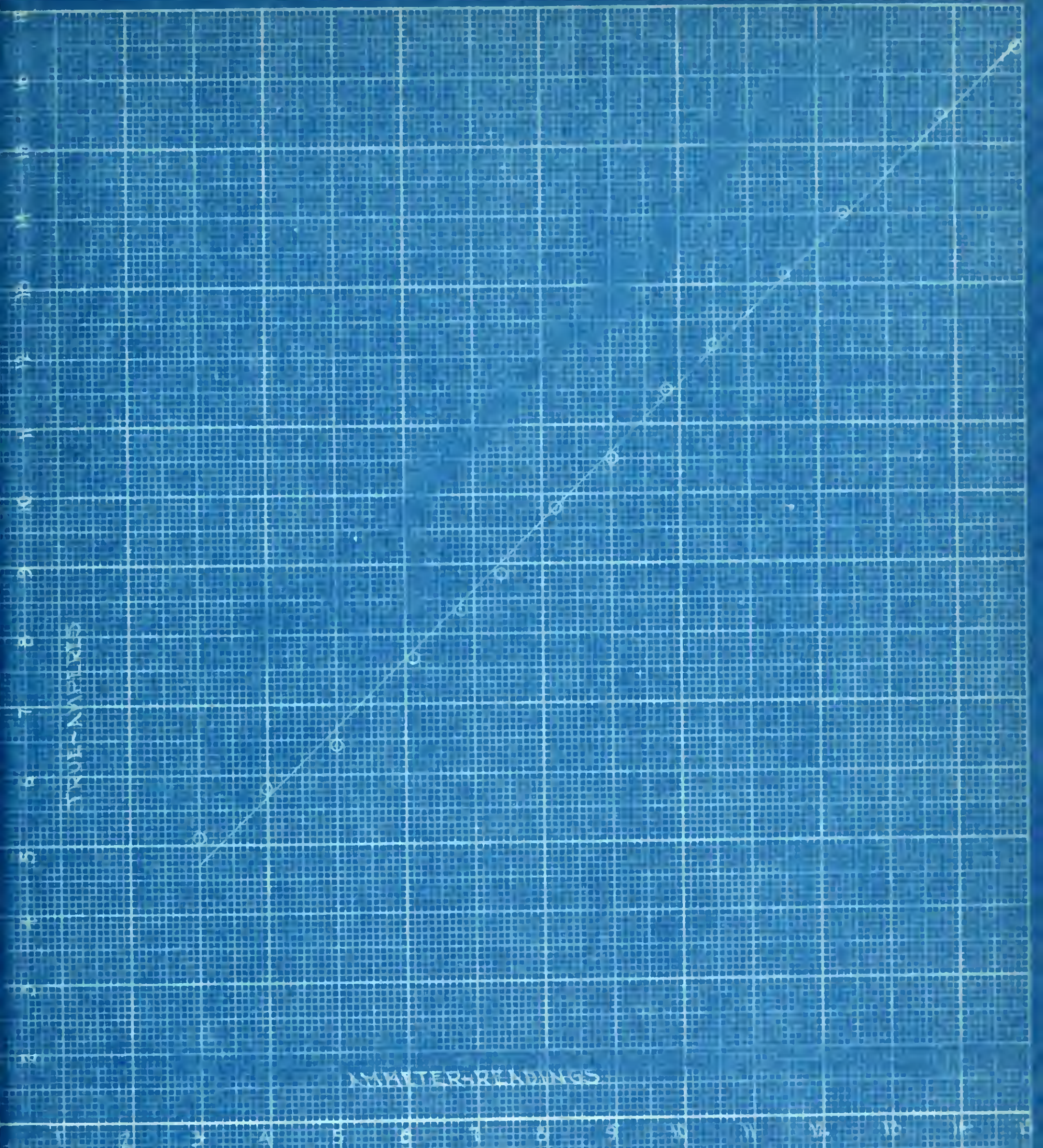




EUGENE DIETZGEN CO. CHICAGO NEW YORK

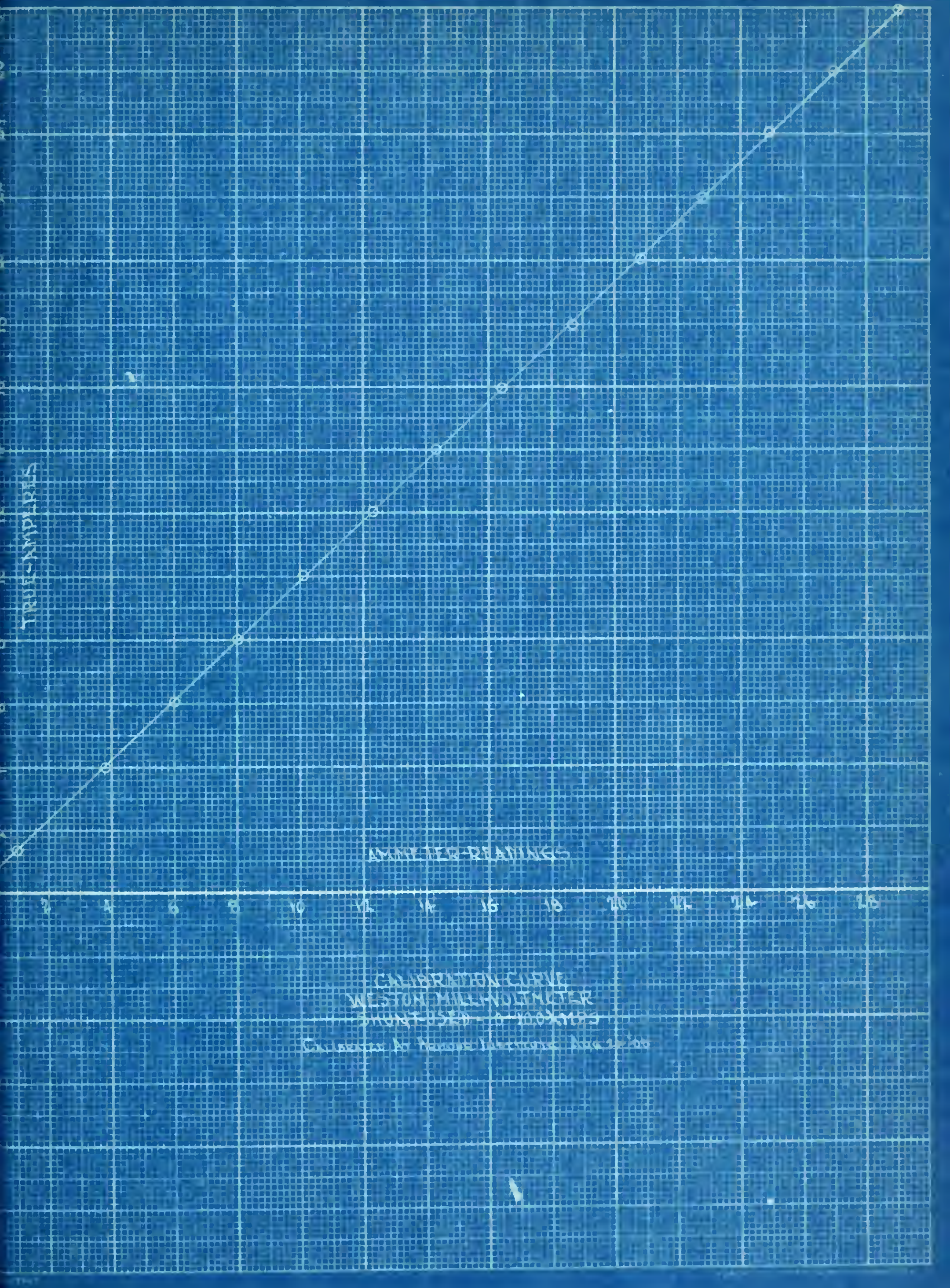



CALIBRATION CURVE
NOYES DYNAMOMETER WATTMETER [illegible]
150 VOLTS 40 AMPS
CALIBRATED AT ARMOUR INSTITUTE [illegible]

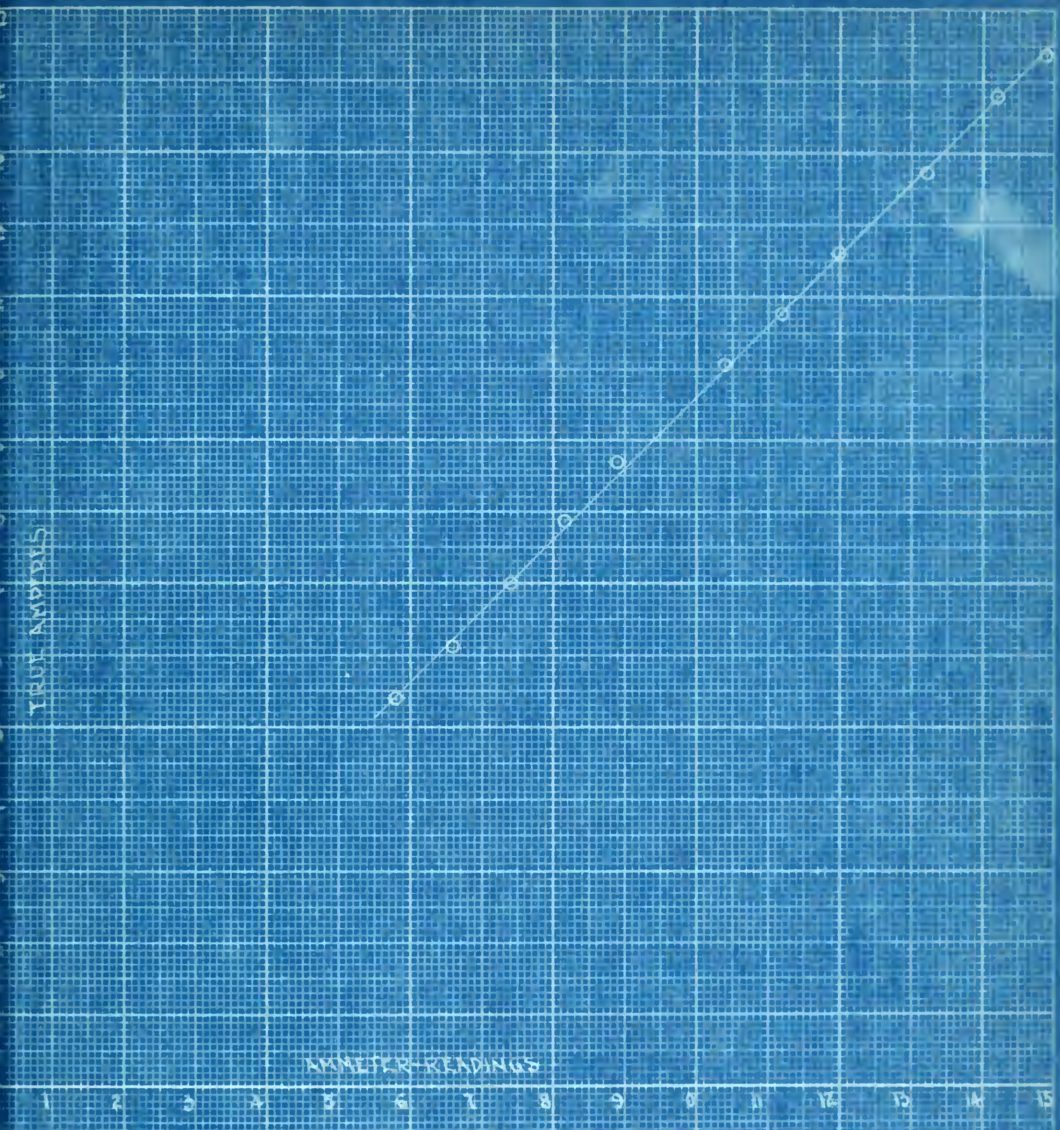


CALIBRATION-CURVE
BRISTOL-RECORDING-AMMETER
SCALE-0-40-AMPS

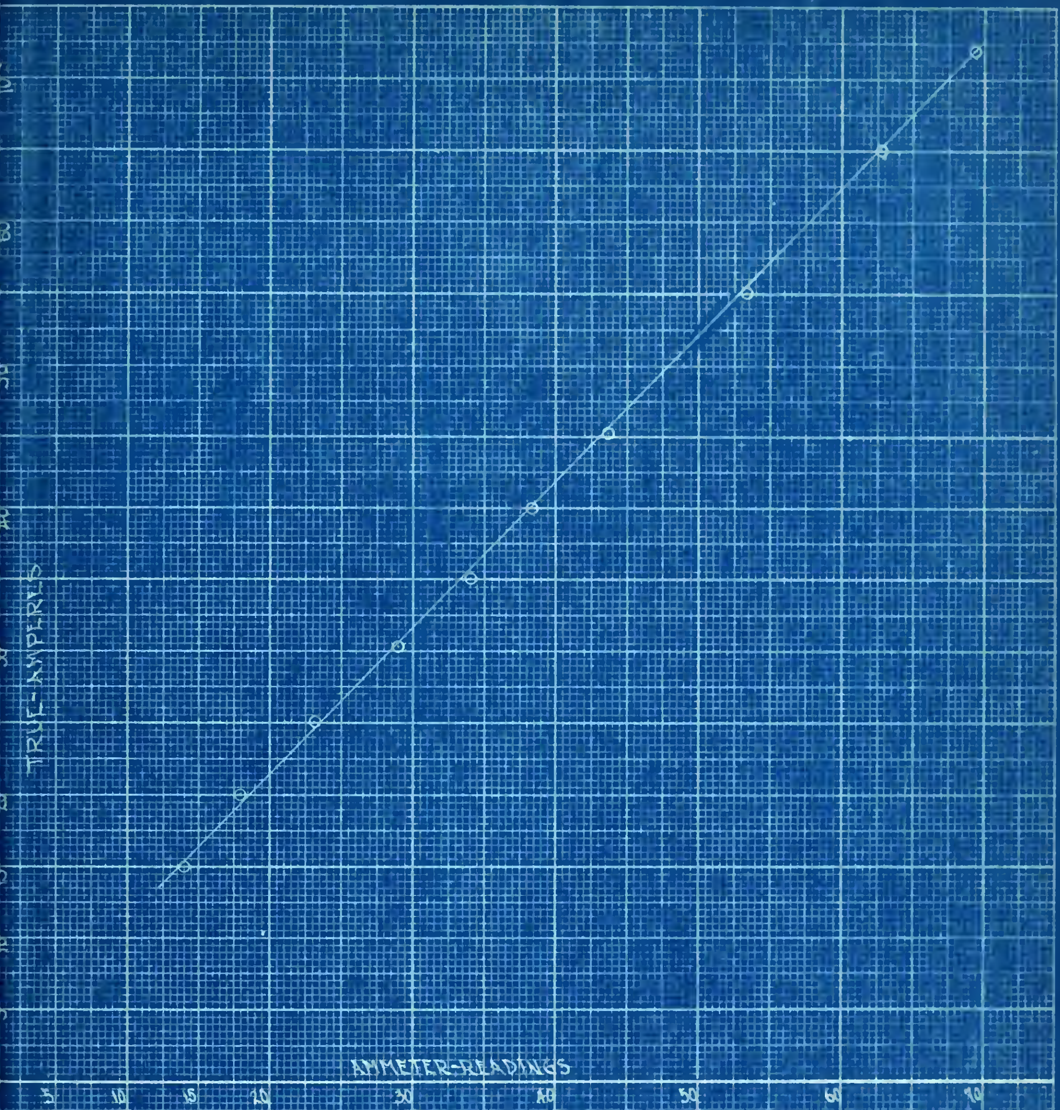
[illegible]



CALIBRATION CURVE
WESTON MILLIVOLTMETER
SHUNT USED — 100 AMPS
Calibrated At [illegible] Nov 25 '06



CALIBRATION CURVE
OF
THOMPSON A.C. AMMETER No. [illegible]
SCALE 0–15 AMPS
Calibrated at Armour Institute [illegible]



CALIBRATION CURVE
THOMPSON A.C. AMMETER # 11291
SCALE - 0-100 AMPS
Calibrated At Armour Institute Apr 24 08

MACHINE	MOTOR REQ'D ELEC-WORD	MOTOR REQ'D WESTINGHO
10" WOOD LATHE	1 - HP	½ HP
24" " "	2 "	
36" BAND SAW	2 "	2 "
SINGLE SPINDLE WOOD SHAPER	3 "	
VERTICAL MORTISER	1 "	
HUB BORER AND SETTER		
18" CIRCULAR SAW	5 "	
12" BUZZ PLANER AND JOINTER	2 "	
24" CIRC. SANDER (DRUM-TYPE)	1 "	
18" RIP SAW	3 "	
24" SWING SAW	5 "	2 "
SAW SHARPENER-EMERY WHEEL	½ "	
2½" BOLT THREADER	1 "	
30" ENGINE LATHE	2.5 "	3.5 "
30" DRILL PRESS	2 "	1.8 "
70" BULL FACING LATHE	3 "	
6" DRILL PRESS	¼ "	.36 "
18" ENGINE LATHE	2 "	1.7 "
20" " "	2 "	2 "
28x28" AT PLANER	5 "	5 "
20" DRILL PRESS	1 "	1 "
16" SPEED LATHE	½ "	1 "
24" " "	2 "	2.6 "
26" DRILL PRESS	2 "	1.56 "
OILING SEPARATER EMERY WHEEL TUMBLER		
6" PIPE THREADER	3 "	
22" TURRETT LATHE	2 "	2.3 "
12" EMERY WHEEL		
3½" PIPE THREADER	2 "	
18" SHAPER	3 "	3½ "
24" "		5 "
#7 BUFFER WITH BLOWER		
#6 BLOWER 30" BLADE		
#4 " 24"		
TIRE BENDER		
EMERY WHEEL 18"		
[illegible] ELEVATOR ([illegible] SHOP)		
MACHINE SHOP ELEVATOR		
HACK SAW		
42" GRIND STONE		

MOTORS REQUIRED TO DRIVE

MACHINE	MOTOR REQ'D ELEC-WORLD	MOTOR REQ'D WESTINGHO	MOTOR REQ'D KENT	MOTOR REQ'D M'FGRS	MOTOR REQ'D TEST	RECOMM-ENDED
10" WOOD LATHE	1 - HP	½ HP	½ HP	½ HP		½ HP
24" " "	2 "		1 "	1 "	1.4 HP	2 HP
36" BAND SAW	2 "	2 "	1 "	2 "	2.08 1.40 HP	2 "
SINGLE [illegible] WOOD [illegible]	5 "			½ "	.425 "	½ "
VERTICAL MORTISER	1 "			1 "		1 "
HUB BORER AND [illegible]			½ "			½ "
18" CIRCULAR SAW	5 "			2 "	2.4 "	3 "
12" BUZZ PLANER AND JOINTER	2 "		3 "	1½ "	2.04 "	2 "
24" CIRC - SANDER (DRUM-TIRE)	1 "			1½ "	1.5 "	2 "
18" RIP SAW	3 "			1 "	2.0 "	2 "
24" SWING SAW	5 "	2 "	3 "	3 "	2.84 "	3 "
SAW SHARPENER & EMERY WHEEL	½ "		½ "			½ "
2½" BOLT THREADER	1 "			1½ "		2 "
30" ENGINE LATHE	2.5 "	3.5 "		3 "		3 "
30" DRILL-PRESS	2 "	1.8 "	1 "	2 "		2 "
70" BULL FACING LATHE	3 "		.91 "	3 "		3 "
6" DRILL - PRESS	¼ "	.36 "		¼ "		¼ "
18" ENGINE LATHE	2 "	1.7 "	1 "	1 "	.835 "	1 "
20" " "	2 "	2 "		1 "		1 "
28X28"X7' PLANER	5 "	5 "	3½ "	5 "		5 "
20" DRILL PRESS	1 "	1 "		1 "		1 "
16" SPEED LATHE	½ "	1 "		1 "		1 "
24" " "	2 "	2.6 "		2 "		2 "
26" DRILL PRESS	2 "	1.56 "	2 "	5 "		2 "
FILING SEPARATER EMERY WHEEL TUMBLER					2.91 "	3 "
6" PIPE THREADER	3 "				1.9 "	2 "
22" TURRETT LATHE	2 "	2.3 "		3 "		2 "
12" EMERY WHEEL				2 "	1.8 "	2 "
3½" PIPE THREADER	2 "		3/4 "	1 "		1 "
18" SHAPER	3 "	3½ "		2 "		2 "
24"		5 "		3 "	1.43 "	2 "
*7 BUFFER WITH BLOWER				5 "		3 "
*6 BLOWER 30" BLADE				3.31 "	2.75 "	3 "
*4 " 24"				2 "	1.56 "	2 "
TIRE SANDER					.76 "	1 "
EMERY WHEEL 18"				3 "	1.8 "	2 "
PATTR[illegible] ELEVATOR [illegible]					3.12 "	3 "
MACHINE SHOP ELEVATOR				3 "		3 "
HACK SAW				¼ "	.17 "	½ "
42" GRIND STONE				1 "		1 "

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[illegible]

ESTIMATED-COST-OF-MOTOR-INSTALLAT

MACHINE OR GROUP OF MACHINES	COST OF PRESENT LOSS IN TRANSMISSION & SHAFTING	ESTIMAT'D YEARLY SAVING OF TRANSMISSION (MOTOR DRIVE)	TRANS-LOSSES (MOTOR DRIVE) @ 2½%	LOSS IN STEAM ENGINE PER YEAR	LOSS IN MOTORS PER YEAR	LOSS IN TRANSFORMERS PER YEAR (AVRGE LOAD)	COST OF LIGHTING SANITARY DIST-POWER	PRESENT OPER COST (AVRGE LOAD LESS FRICTION LOSSES) STEAM ENGINE	COST FOR EQUAL LOAD (MOTOR DRIVE) S-D-POWER	ESTIMAT'D COST OF OPER'TNG STEAM HAMMER	TOTAL PRESENT OPERATING COST (AVRG LOAD)	TOTAL OPERATING COST (MOTOR DRIVE) EQUAL LOAD	COST OF MOTORS	COST OF TRANSFORMERS	COST OF LABOR & MATERIAL AND TRANSFORM'R-ROOM	CABLE & DUCTS TO SHOPS FROM 22nd ST & ASHLAND #2/0 CABLE	PORTION OF COST OF TUNNELS UNDER I-M CANAL & RIVER	PORTION OF COST OF TRANS-LINE CHARGEABLE TO SHOPS
WATER PIPE MACHINE SHOP				371.00	215.00	215.00	160.00	1175.70	587.85	135.90	2974.40	1459.18		1074.00	1500.00	935.00	108.20	444.00
PATTERN-ROOM	78.22	78.22											72.00					
SO-BALCONY-LINE	78.22	11.42	33.40										72.00					
No & W-BALCONY LINE	450.50	228.40	111.55										226.00					
ELEVATOR	57.10	57.10											72.00					
FIRST FLOOR SO-LINE	62.80	17.13	22.83										255.00					
FOUNDRY-LINE	222.70	222.70																
FORGE-BLOWER													72.00					
NORTH LINE	342.30	114.20	114.05										255.00					
HYDRANT-LATHE													79.00					
BRASS FOUNDRY													72.00					
GRIND STONES													63.00					
PIPE-SHOP													63.00					
TOTALS	1291.84	729.17	281.83	371.00	215.00	215.00	160.00	1175.70	587.85	135.90	2974.40	1459.18	1301.00	1074.00	1500.00	935.00	108.20	444.00
POLICE-SHOP	52.40	41.90	32.00		86.00	86.00	INCLUDED-IN-POWER BILLS	443.00	585.00		516.98	782.00		443.47		386.50	44.66	183.20
BUFFER & BLOWER													72.00		850.00			
MACHINE TOOLS	21.50																	
BANDSAW & SANDER													72.00					
CIRC SAW & PLANER													79.00					
REMAINING WOOD-WORKING MACHINES													63.00					
BLACK SMITH-SHOP PATROL-ELEVATOR													72.00					
FORGE-BLOWER													63.00					
EMERY-STONE													63.00					
TIRE BENDER-DRILL PRESS & THREADER													63.00					
TOTALS	73.90	41.90	32.00		86.00	86.00		443.00	585.00		516.98	782.00	547.00	443.47	850.00	386.50	44.65	183.20
WATER PIPE-DEPT WOOD SHOP & SAW MILL	49.40	44.46	3.30		4.30	4.30		74.10	49.70		123.50	58.30	261.00	155.00	500.00	135.50	15.65	64.30
SUM-TOTALS	1415.14	815.53	317.13	371.00	305.30	305.30	160.00	1692.88	1222.55	135.90	3614.88	2299.48	2109.00	1672.47	2850.00	1457.00	168.50	691.50

ESTIMATED EXPENSES COST OF MAKING CHANGE	MACHINE SHOP W.P. EXT-DEP'T	MACHINE SHOP POLICE DE'PT	SAWMILL WATER-PIPE EXT DEP'T
COST OF MOTORS	1301.00	547.00	261.00
COST OF TRANSFORM'S	1074.00	443.47	155.00
COST OF INSTALLATION	1500.00	850.00	500.00
COST OF CABLING & DUCTS FROM 22nd ASHLAND	935.00	386.50	135.50
PORTION OF COST OF TUNNELS UNDER RIVER & I-M CANAL	108.20	44.66	15.[illegible]
PORTION OF COST OF TRANS-LINE CABLE TO SHOPS	444.00	183.20	64.[illegible]
TOTALS	5362.20	2454.82	1131.[illegible]
YEARLY EXPENSES TO BE CARRIED			
INTEREST @ 4% ON COST OF MAKING CHANGE	214.48	98.19	45.28
COST OF POWER	1459.18	782.00	58.[illegible]
MTCE @ 4% PER YR	214.48	98.19	45.28
SINKING FUND 8% OF COST OF CHANGE COMPOUNDED @ 4% INTEREST PER YR	428.96	196.38	90.80
TOTALS	2317.10	1174.76	239.80
SUM-TOTALS	$3731.16		
PRESENT EXPENSES			
COST OF POWER PER Y'R	2974.40	516.98	123.50
COST OF MAINTENANCE	650.00	325.00	150.00
TOTALS	3624.40	841.98	273.80
SUM-TOTALS	$4739.38		

TOTAL PRESENT EXPENSES PER YEAR $4739.38

TOTAL ESTIMATED EXPENSES PER YEAR 3731.16

ESTIMATED YEARLY SAVING $1008.22

NOTE — THE TOTAL ESTIMATED COST OF THE MOTOR INSTALLATION IS $8948.41

FULL VALUATION HAS BEEN PLACED ON MACHINERY THROWN OUT OF SERVICE BY THE INSTALLATION OF AC MOTOR DRIVE.

* NOTE — COST OF ATTENDANT WILL BE THE SAME AS AT PRESENT WITH MOTOR DRIVE.

— 8% DEPRECIATION ON THE ESTIMATED COST PUT INTO A FUND AND COMPOUNDED @ 4% INTEREST WILL PROVIDE FOR A COMPLETE RENEWAL OF THE INSTALLATION AT THE END OF THE TENTH (10TH) YEAR.

October 19, 1908.

Mr. Wm. Carroll.

Dear Sir:

I beg to submit herewith detailed report on the advisability of operating the municipal shops; located on Ashland Ave. south of Blue Island Ave. with electric drive, using"Sanitary District" power.

I have estimated the total cost of making this change to be $8948.67, while the yearly saving in cost of operation is $1008.72. This credit balance remains after having made provisions for rehabilitating the plant at the end of ten years, paying 4% interest on the money required to make the change and allowing 4% of the original cost of the units, for their maintenance.

The present and estimated expenses have been tabulated in detail and embodied in the attached report.

These conclusions have been reached partly, through electrical and steam tests made at the shops, and partly, through assumptions based on standard American practice.

Consideration was given to the reliability of continuous service from the "Sanitary District" system as compared with the present method of operation, and I have concluded the former as good if not better than the latter.

As an appendix to this report I have suggested that a low pressure boiler be installed for heating the buildings. By

so doing considerable of the present expense which is $1716.00, could be saved. This installation would not require an extra attendant. The man in charge of the motors could easily fire the boiler.

From this report it is apparent that the substitution of motors for the present drive is quite advisable and I wish to strongly recommend the same.

Awaiting your instructions in this matter, I beg to remain,

Yours respectfully,